UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION

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INCENTIVE AUCTIONS

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LEARN WORKSHOP - 600 MHz BAND PLAN

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FRIDAY,
MAY 3, 2013

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The Workshop was held in the Commissioners' Meeting room at FCC Headquarters, 445 12th Street, S.W., Washington, D.C., at 9:30 a.m., Tom Peters, Moderator, presiding.

INDUSTRY REPRESENTATIVES PRESENT:

JAY ADRICK, Harris Broadcast
CHRISTIAN BERGLJUNG, Ericsson, Inc.
DARRYL DeGRUY, U.S. Cellular
TOM DOMBROWSKY, CTIA
RICHARD ENGELMAN, Sprint Nextel
HAROLD FELD, Public Knowledge
GEORGE HARTER, Clearwire
DALE HATFIELD, University of Colorado at Boulder
DOUG HYSLOP, CCA
KARRI KUOPPAMAKI, T-Mobile USA
BRIAN MARKWALTER, CEA
PRAKASH MOORUT, Nokia Siemens
WILL MUELLER, Avago Technologies
PRESTON PADDEN, Expanding Opportunities for Broadcasters Coalition
JIGNESH PANCHAL, Verizon

SANYOGITA SHAMSUNDER, Verizon
DELROY SMITH, Philips
CRAIG SPARKS, Sprint Nextel
DAVID STEER, BlackBerry
NEETI TANDON, AT&T
VICTOR TAWIL, National Association of Broadcasters
SUMIT VERMA, Qualcomm
KENT WALKER, Qualcomm
STEVE WILKUS, Alcatel-Lucent

FCC STAFF PRESENT:

TOM PETERS, Moderator
MICHAEL HA
CHRIS HELZER
EVAN KWEREL
RUTH MILKMAN
CECILIA SULHOFF
JENNIFER TOMCHIN
BOB WELLER

T-A-B-L-E O-F C-O-N-T-E-N-T-S

P-R-O-C-E-E-D-I-N-G-S

9:31 a.m.

MS. SULHOFF: Good morning, everybody. Thank you for coming today to our workshop. My name is Cecilia Sulhoff. I'm a wireless liaison specialist in the Wireless Telecommunications Bureau here at the FCC.

Before we get started, there is a couple of quick housekeeping things I need to go over.

We do have some sign-in sheets at the back of the -- at the back table back there, so we have some for attendees and then one for the press. So if you could, please, sign-in if you haven't already done so.

Also, we are streaming this workshop live on the web. We also have a court reporter in the room, because we want to make sure to get an accurate transcript of the workshop for the record. So, please, make sure the speakers and FCC staff, as you are speaking, I know sometimes you will turn to look at somebody, but please make sure you are speaking into the microphone, so that we pick up every -- all the conversation today.

We have a couple of documents on the back table. We have got a program which includes the agenda for the day along with some speaker information. We have some FCC staff here and then we have the participants up here at the table. We have biographies.

As you can see, we have quite a number of participants here, so we are not going to go over with individual introductions, because we have a lot of information to get through, so, please, refer to the program with the bio information on the speakers.

We also have back there the Band Plan illustrations that we have blown up here. We have a smaller version back there, so if people are referring to it throughout the day, you can have it in front of you.

For those watching remotely, we do have the program and the Band Plan illustration on the LEARN webpage or if it's not there, it should be there shortly and on the events webpage, if you go to www.fcc.gov/events and click on the 600 MHz Band Plan.

We also have some information about the FCC Guest Wi-Fi. We have changed up the system a little bit so you need an access key and stuff, so we have sheets back there with that information, if you want to access our Wi-Fi here.

We also have one more piece of information, which is for lunch. There is a couple of nearby restaurants. We will have a break for lunch and come back, so there is some information back there.

You are -- you will be allowed to ask questions throughout the day. The workshop is a little different this time, in that we are not having individual panels. It is going to be a day-long roundtable discussion, so please, as you think of questions, submit them through out the day.

There is not going to be a designated time for Q&As at the end of a different panel or topic.

The people sitting here, we have some notecards in the back and some pencils, if you didn't already pick some up, there will be some FCC staff wandering through the room, please, write down your question on the notecard and hand it -- raise your hand, and hand it to the FCC staff and we will make sure it gets to the moderators.

Those watching remotely can send an email to livequestions@fcc.gov. Please, include your name and your company affiliation with all of your questions today. And please, like I said, do it throughout the day as you think of them. Given the time constraints and the volume of questions we have, we will get to as many as we can.

Now, I would like to introduce Ruth Milkman. Ruth is the Chief of the Wireless Telecommunications Bureau and my boss here at the FCC.

MS. MILKMAN: Good morning. Welcome to the LEARN Program Workshop on the 600 MHz Band Plan. Thanks hugely to all the technical experts who are gathered here to participate in this roundtable discussion. We really appreciate your coming in to give us the benefit of your thinking and analysis.

This workshop is being held as part of the FCC's LEARN Program, which is designed to provide stakeholders with information about business opportunities created by the Incentive Auction as well as the proposed Incentive Auction process.

The spectrum repurposed through the Broadcast Incentive Auction will promote economic growth and enhance America's global competitiveness increasing the speed, capacity and ubiquity of mobile broadband services, such as 4G LTE along with Wi-Fi-like networks.

This proceeding is an important component of the Commission's unprecedented commitment and efforts to make additional licensed and unlicensed spectrum available for broadband.

One of the key elements of the Incentive Auction is the 600 MHz Band Plan. In the Notice of Proposed Rulemaking on the Broadcast Incentive Auction, the Commission identified five key policy goals for the band plan: Utility, certainty, interchangeability, quantity and interoperability.

And as we discuss the technical issues today, let's all keep these in mind, because they provide the framework for the decision making on this issue.

(1) **Utility**. We want to make sure that the spectrum is configured in a way that is useful and useable for the intended purpose, flexible wireless use, including broadband services.

(2) **Certainty**. It has been our experience that certainty about the operating environment provides a solid foundation for investment, while uncertainty can delay

investment and therefore delay service to consumers.

(3) **Interchangeability**. Generic spectrum blocks that are technically and functionally interchangeable would give us additional flexibility in our auction design choices and in particular enable a forward auction to be conducted in a more compressed time frame.

(4) **Quantity**. A primary goal of the Broadcast Incentive Auction is to maximize the amount of spectrum we can repurpose for broadband services, both licensed and unlicensed. And the Notice sought comment on the concept of variable amounts of uplink spectrum, which would avoid the least common denominator problem.

(5) **Interoperability**. That is a core Commission objective and the design of the band plan can either promote or impair interoperability.

We are hoping that today's discussion will bring into relief the trade-offs that are implied by various options, so that the Commission can incorporate that information into the decision making process.

I would like to thank the FCC Team that worked on this event, Sandra Danner, Susan Fisenne, Madelaine Maior, Paul Malmud and Cecilia Sulhoff, as well as our group of moderators, who will be introduced in a moment.

I'm looking forward to listening to a robust and informative discussion on all these issues. Now, I would like to turn it over to Chris Helzer, who is an engineer in the Broadband Division of the Wireless Bureau and Chris is going to provide a brief overview of some of the 600 MHz Band Plan proposals. Chris?

MR. HELZER: Thanks, Ruth. And thanks, everybody, for coming today. I'm mainly going -- well, obviously, we are here to talk about the band plan and, obviously, there is not just one band plan, at this point, there are a lot of band plan proposals in the record.

And so we put together this chart to

try to keep you oriented during the day. This is up here and it's also in your handouts. And all these band plans have pluses and minuses and so the purpose of today's discussion is to try to better understand the trade-offs between them. But I'll talk briefly about what they are.

So this first one is -- well, first of all, because it's easy to lose track, we have the frequencies and the band and megahertz across the top and we have all the TV channel numbers, so as people refer to these things during the day, you can try to keep oriented.

And we have a little note here that this UHF Band is next to the 700 MHz uplink, which is somewhat relevant.

The Green Plan is one that we call "down from 51 and 36," which is one of the options in the NPRM. This plan is -- I want to use to kind of illustrate the fact that there are two levels of variability that we are trying to support in all these band plan proposals.

The first one is this Incentive

Auction, this market-based mechanism, where we are collecting bids to sell stations and bids to use stations for wireless and we don't know how much spectrum will be repurposed. We may have an auction that repurposes a small amount of spectrum, 60, 72 MHz. We may have a lot, 120, 156. Any of these things are possible.

And so that's the first level of variability that you have to support and that's where it says variable clearing on this plan. And so all of these are really what we call band plan frameworks. They are different frameworks for how a given market result would be translated into a band plan.

The second issue is, you heard Ruth mention, the least common denominator issue, which is while you want to have the same, we envision that, you know, in most markets the same amount of spectrum will be repurposed.

And the band plan will be basically uniform, but we want to account for the possibility that there may be some markets in which there is very low participation or technical constraints due to coordination with Mexico and Canada. And we don't want to have a situation where the market result, in most markets, was 120 MHz, but a few markets you can only clear 84 or 66. And therefore you have to do 66 everywhere. And so that is what is called -- what we are calling "market variation." In this first proposal, that is handled through keeping the downlink uniform, but allowing the uplink to vary, because that allows you to have a single mobile device that works across the country, but still allows you to have some variation in your band plan.

And so that is kind of shown here where the second line in the green shows that in a constrained market, you would reduce the amount of uplink. That also means some of the downlink loses its uplink, so it can only be used for supplemental downlink. So that's one proposal that kind of explains the two levels of variation we are trying to support.

Another proposal was this down from 51. Well, before I leave this, the thing that -- this plan features a -- and actually talks about why it's called 51 and 36. The uplink is anchored to 51 and the downlink is anchored to 36. And so they are fairly widely separated. It's kind of a widely separated uplink and downlink model, which has received a lot of comment in the record.

That is kind of -- it's similar to AWS-1 where you have an uplink and a downlink that are very far apart and services in between.

The opposite of that is kind of this down from 51 proposal, which is also in the NPRM. And in this case, you do not -- you don't have wide separation. You keep them close together and you keep all the wireless service in the 600 band contiguous.

And as envisioned in the NPRM, it has -- it also supports the same possibility of, you know, a small amount of spectrum being repurposed or a large amount of spectrum being repurposed.

If you just have an uplink, a duplex gap, a downlink and a guard band, if you clear or not clear, repurpose more than 84 MHz, you do end up passing 37, so you have to have services on both sides of 37.

Just to talk briefly about some of the trade-offs, on the plus side -- like if you compare these two in terms of quantity, which is one of the five things we are interested in, they are similar. If the repurposing is less than 84 MHz, this one has a duplex gap and a guard band. This one has two guard bands and it doesn't need a guard band here at the other side of the downlink, because it -- or not much of one, because it can take advantage of 37 providing some separation between TV and downlink.

I think I forgot to mention channel 37 is not a television channel. It is used for radio astronomy and wireless medical telemetry.

So for less than 66 MHz, they are similar. This is slightly lower quantity in that most commenters have suggested the duplex gap needs to be a little larger than a guard band, but they are similar.

At 84 MHz down from 51 is actually a higher quantity plan in that exact case because in that case you can use 37 -- the separation of 37, greatly reduces the guard band you need at the edge, but if you clear more than 84, that's a somewhat lower quantity plan because you have the duplex gap, the guard band and you tend to have some -- a few megahertz around 37 because the blocks don't work out equally. So that's kind of an example of one of the trade-offs.

On the other hand, a lot of commenters have suggested that there are a lot of interference issues having -- and other issues, bandwidth issues, having to do with antennas and intermodulation and harmonics that mean that while this may be a higher quantity of blocks, it may not be the highest quality blocks. And so that's one of the trade-offs we have to talk a lot about today and that's what much of the agenda is focused on is these different technical issues and how they affect all these proposals.

This purple one is an attempt to summarize the common features of a number of proposals that were in the comments. This is not any specific proposal, but it kind of characterizes several proposals on the comments and those are proposals that are based on this down from 51 idea, but I'm calling it a down from 51 hybrid here, because they tend -- several of these proposals suggest that due to these various technical issues, you should start with a paired band that is of a fixed size, either 25 plus 25 MHz or 35 plus 35 MHz for most of the proposals.

And then if the market-based result is that you get more than that, then there is -- the proposals all kind of differ. And what you do after that, some of them suggest a second paired band, but most of them suggest a supplemental downlink or TDD or unpaired spectrum after you clear that first amount, which varies somewhat by the proposal.

So in that case, you do still have the ability to support a lot of different auction results, but you have a constraint, so it may be that if the -- you may be limiting the amount of paired spectrum to 25 plus 25, so there is a possibility that you had a lot of broadcasters who wanted to sell and carriers who wanted to buy, but because the supply of paired spectrum was limited, you may kind of constrain the auction-based result.

And a lot of commenters have said that paired spectrum is really significantly more important to them than supplemental downlink. And so that may be an issue, but you certainly can support a wide variety of different amounts cleared. You just have the second band that is either TDD or FDD or supplemental downlink, depending on the proposal or maybe is even more flexible and bidders can choose among those things possibly.

The other thing is, of course, all these markets do -- there is this kind of fixed minimum of 25 plus 25 or 35 plus 35, but all commenters have tried to suggest ways that can address the constraint problem and the least common denominator problem.

I didn't show them here because they are all kind of different. Some of them suggest that you would follow this type of model and shrink the uplink and put a few TV stations in there. Others suggest you should do that, but you should limit the power of those TV stations to say 50 kilowatts or some number like that.

Other ones suggest that you can't do that, but you could put a second supplemental downlink band that is lined up with that duplex gap that you could use in markets where you can't clear the paired spectrum. So there are a variety of ways to try to deal with constrained markets in this case.

And the last thing that is in the record is there is a few commenters who suggested that an all TDD Band Plan would actually be a better way to address a lot of these trade-offs.

So it's a kind of simple plan. It's just TDD all the way down, as much as you clear, you clear, so it's very good for supporting a wide variety of auction results.

It is -- on the quantity side, it does need a guard band up here, because you don't have the uplink aligned with 700 that you have in all the other plans. But on the other hand, you don't need a duplex gap.

And so whether -- the size of that trade-off depends on a lot of your assumptions about how much a guard band you need in these different cases for interference.

Market variation isn't discussed as much in these, but we may discuss this some during the filter discussion. Certainly if the TDD Band is implemented with a series of filters, then it is possible that in some markets you don't need all the filters and so you can support some constrained markets that way.

But those are just some of the trade-offs. When we have to talk today, we will be talking about all these different technical issues that have come up with all these plans to try to get a good input on the trade-offs.

I mean, our goal today is to -- we see pluses and minuses with everything. We want to do as much as we can today to help quantify those trade-offs so we have the best information to eventually make a decision on what the best framework for the auction is.

And so I appreciate all of you coming here and offering your input on all these issues and I think we will start the first panel. Thank you.

MS. SULHOFF: So as Chris said, we are going to get started with our discussion today. We have several FCC staff here that are going to be acting as moderators throughout the day for the several different topics we are going to talk about.

We have Tom Peters, who is the Chief Engineer in the Wireless Bureau.

We have Chris Helzer, who is an

engineer in the Broadband Division in the Wireless Bureau, who just gave that wonderful overview.

We have Michael Ha, who is an engineer in the Office of Engineering and Technology.

We have Robert Weller, who is Chief of the Technical Analysis Branch in the Office of Engineering and Technology.

Evan Kwerel, who is the Senior Economic Advisor in the Office of Strategic Planning and Policy Analysis.

And Jennifer Tomchin, who is the Deputy Chief in the Broadband Bureau in the Wireless Bureau. Broadband Division in the Wireless Bureau, sorry.

MODERATOR PETERS: Great. Thank you, Cecilia. Good morning. I'm Tom Peters. Thank you for coming. Before we begin the first session, let me just -- I would like to maybe set the tone a bit about what the expectations/goals of today are.

Of course, the subject of today's discussions are the technical challenges associated with various band plan framework options for the 600 MHz Band.

Now, as engineers, we all know that most of the time if you remove all the practical constraints, pretty much any technical challenge can be overcome. The problem is that sometimes those practical constraints are pretty important or that the costs of providing a particular solution is just too high.

And when deciding between various options, engineers have to make trade-offs, as Chris discussed and as Ruth discussed in her opening remarks.

Sometimes, you will hear engineers say that, you know, no, that option simply can't be done. It's impossible. But when we say that, what I think we really mean is that the cost of solving the technical challenges of that particular option are just too high relative to the cost of -- associated with some other option or that the practical constraint that we needed to break to achieve the solution was just too important to break. It was one that we just didn't -- we couldn't violate.

It generally means that the trade-offs associated with another option have less total impact on the end result. And often the value of these costs are not explicitly stated, but it is critical to our understanding of why one option is inferior to another to understand what those values are.

Now, what am I talking about when I say costs? I mean, specifically for our purposes here, I'm talking about costs in terms of perhaps increased device size driven by the antenna, degraded performance is a popular one, reduced spectrum support, higher manufacturing costs perhaps or even things like the risk of relying on nascent unproven technologies in order to solve a particular technical challenge.

And of course, just looking at these few examples, it is easy to see that there is some implied judgment here on how these factors should be weighted when determining the total impact of one option versus another.

And again, these weightings are often not explicitly stated, but they are also very critical to understanding how we arrive at the conclusion that one option is superior to another.

So I want to stress that it is these costs and weightings or trade-offs that the FCC staff here is responsible for evaluating. And in that light, we hope to achieve in this workshop a better sense of the quantity of these costs, so that we can compare the pros and cons of different band plan options and apply sound judgment to make the right decision regarding the band plan for this new 600 MHz Band.

Ultimately, our success is going to be defined by how well the resulting band plan meets the needs of both wireless operators and broadcasters in the United States and perhaps later, ideally, hopefully later, we will see how well the band meets the needs of stakeholders from around the globe.

Certainly from a band plan perspective, creation of a globally adopted band would be a great success. So there is a healthy amount of pressure on us to get this right. And our goal with this workshop is to be as informed as possible, so that we can make an appropriate data-driven decision on this very important multi-faceted and technically complex issue.

So with that, we can jump into the first topic of discussion, which is interference issues related to these various band plan framework options.

Now, there is four general categories of interference that I think we want to go through and I'll run through them now. One is intermodulation, another is harmonics, a third one is co-channel issues mainly related to the market variability that Chris talked about, and the fourth one is adjacent channel interference with Channel 37.

I want to make sure we have time to address each one of these topics in the hour and 15 minutes or so that we have, so, please, keep that in mind when giving your response.

I'm not sure if Cecilia mentioned, but I'll mention it again. The way we were hoping to run this was similar to the way the TAC runs where if you have -- if you want to speak on a particular issue, if you could place your tent card this way, then we will see who is willing to speak. Apparently, there is technical difficulties with the audio.

Should I pause?

PARTICIPANT: Just tell the people on the web that they are working on it.

MODERATOR PETERS: Okay. We are working on the technical difficulties associated with the audio, so, please, stand by.

So in any case, we will try to run it that way and see how it goes. So let's start with the intermodulation.

Intermodulation. This has been

brought up in the context mostly of that some band plan proposals, including the one proposed in the NPRM, have TV channels in the duplex gap. However, other options that Chris went through may also end up having TV stations in the duplex gap and, therefore, this is a big concern to us, the issue that intermodulation could cause self-interference to mobile devices.

So I'm wondering maybe the best way to start is to have someone describe the issue, someone who can tell us what the issue exactly is. Is it forward intermodulation that would occur in the LNA of the mobile receiver or reverse intermodulation which would occur in the power amplifier of the mobile device? Is there -- there we go. Sumit, please.

MR. VERMA: Yes, I think the most straightforward way to probably look at it would be to start with the very first band plan proposed, the down from 51 and 36, where it would be, I'm guessing, probably difficult to not have TV in the duplex gap.

And there that is, in fact, one of the central technical challenges is that there would be a TV channel that would be in what we would call the (TX+RX)/2 spot. And what that would lead to is a third-order intermodulation product that would fall in the UE downlink.

Now, as far as where precisely that is created, there are actually multiple sources of that. You have got the reverse intermodulation and the power amplifier in the transmit chain. You do have in the LNA as well the same phenomena, but it's also easy to overlook the front end of the UE where you have switches and other active devices that will also have some finite IP3 and, therefore, create the product.

This puts a lot of burden on any practical duplexer design to provide adequate attenuation before, to basically linearize the solution.

MODERATOR PETERS: Is your assumption that the -- because when we talk about market variability, we are talking about this co-channel issue where you could have TV stations or a piece of the band that is used for DTV in some markets and a piece of the band that is used for mobile broadband in other markets, that same piece of band, sorry.

And is it the assumption that because of this, the TV station could actually be transmitting inside the filter, within the pass band of the filter, such that it wasn't filtered out? And if that's not the assumption, then how much isolation, you know, would be required to protect from this?

MR. VERMA: Yes, that's a good question. We are not necessarily assuming it is inside say the uplink here. I guess I was strictly assuming it would be in the duplex gap where you are sort of in this transition region. And I think it would maybe be hard to know in here, it really depends on the amount of desense that is acceptable as to the performance that would be ultimately placed on the duplexer. But it would not be trivial.

You know, we would be talking about pushing the limits of duplexer technology here to really get acceptable attenuation in the duplex gap.

MODERATOR HELZER: Do you want to add to that?

MR. WILKUS: Thank you, thank you. Can you hear me okay? Very good. I'm Steve Wilkus with Alcatel-Lucent, Chief Technical Office. There are several different intermodulation scenarios to consider. The one here of the television and the duplex gap has the characteristic that if the UE is transmitting at say the high end of Channel 51 of the uplink band, it will be generating its third intermod product at the low end of the downlink band.

And if it is at the low end of the uplink band, it will be at the high end of the downlink band. And so for most of the band, if the uplink and downlink are paired frequencies with a fixed frequency spacing for uplink and downlink, then there is only one case where that might pose a problem, just because the different frequencies are tracked this way. So that's one thing to consider.

Another scenario is for self-interference purely caused by one's own multiple carriers is thinking about the broadband transmissions in the uplink and its third harmonic or third-order intermod products potentially falling into the -- its own downlink band and muting and blocking itself.

The -- what Alcatel-Lucent in a reply comment last March were -- what we indicated is that if you have a 5, a 10 or a 15 MHz-wide uplink block of spectrum that you are transmitting up in, then the third-order intermod products will span three times that bandwidth and will not interfere with its paired downlink spectrum in an FDD configuration. It won't interfere with its own if there is a duplex gap that is 10 MHz wide or more.

If you have the unlikely scenario of

someone getting a 20 MHz allocation, that 20 MHz of bandwidth once you, you know, go through a third-order intermod product generation, it will potentially overlap by just 1 MHz the 20 MHz downlink band, which is perhaps a minor and acceptable level, but that could be cured by having an 11 MHz duplex gap.

So the thinking here is that, you know, there is a tendency to think well, these self-interference issues are something that the terminal manufacturer is responsible for solving. But some band plans that have say a small duplex gap can make it inevitable that there will be this kind of problem.

A smart band plan with a 10 or 11 MHz duplex gap can ensure that it won't ever be a problem. So we encourage the Commission to think about that.

The -- and then finally, I'll just say that there are other scenarios of, you know, two terminals next to each other transmitting at 2 uplinks and they can cause a third-order intermod in one or the other or a third victim band. These things happen all the time. There is no getting around it. We suffer from it. It is a real problem, but it is not something that I think we should let get in the way of proceeding with making progress.

MODERATOR HELZER: I have follow-ups. Christian is next, Doug and David want to raise theirs as well, so, Christian, if you would like to put your two cents in.

MR. BERGLJUNG: Okay. Thank you. I am Christian Bergljung with Ericsson. Whether it is forward or reverse intermodulation, that may also depend on the actual location of your broadcast interferer.

In our reply comments, we looked at the case of a forward case where you have interference and your FCC Band Plan is close to Channel 37. And for that, we looked at input levels of around -30 to -40 dBm. That can happen close to a broadcast station.

And then we looked at the loss that

you would need for the filter -- to the attenuation that you would need from the filter for the forward component would be of the order of 10 to 15 dBs.

However, for the reverse case, the problem may be worse if your interferer is located close to your uplink band, so that your uplink TX filter in the reverse direction has low attenuation, so that may then affect the channels in the low part of the band.

And one such scenario could, for example, be that if you look at, in some markets, allocating frequency towards the high end of the uplink band and then have TV stations in the other, in the low part of the uplink band, then you may get significant interference from the reverse case.

So we would say that this depends on where your interference is located and the physical rejection that you can count on.

MODERATOR HELZER: There are so many cards up. I think how about David Steer. I think you had -- you put your card up a while ago.

MR. STEER: So my name is David Steer. I'm with BlackBerry and so we are one of the device manufacturers. And as Steve said, we are responsible for fixing all of this.

And so I echo the comments that have been made in the sense that the intermod products do come in many different places. And we have to look at not only the ones that come from various TV stations and things that are inherent, but all the other signals that are around.

And I guess that's the very complex problem for us and we have to deal with it and we do deal with it in many cases.

What is typically clear though when we looked at the numbers for what was happening in this particular band and the scenarios we just heard about was the power of the interfering TV signal. And so almost all of the combinations were going to have TV signals in some respect, close to the signals that we are trying to receive.

And what is really important from our perspective in being able to deal with it is to make sure we know what those powers are and, in particular, that they not be too large. And so if we know what they are, we can try and design for it and maybe we won't be able to build it.

What we did when we cranked the numbers through, it looked as though you had to keep -- the one that really frightened me was the 1 megawatt TV station in the middle of a city. And that kind of thing, the calculation I did, it was like half a volt on our front end. And just we can't deal with that, at the moment.

And so those are -- the answer to some of these questions relates to if you can control the signals that we need to deal with, such that they are similar to the mobile base station broadcast transmitters, then there is not a problem. We are able to deal with that. If they significantly exceed that, then these intermod products become a problem for us. Thank you.

MODERATOR HELZER: Okay. So I think

I'm going to say a little bit more and then continue to go around the cards.

So yes, I think one of the key questions coming up here is how much -- clearly there is high power TV in the band and in a number of these plans, certainly in the 36 and 51 there is TV in the duplex gap. And I think to Christian's point and to David's point, you need -- it's reasonable to assume you need to attenuate that to prevent these non-linearities from occurring.

But I think one of our questions is how much isolation do you really need? I mean, Christian was talking about 10 to 15 dB for the case where it is occurring in the LNA and then talking some about concerns about it occurring in the PA.

Similarly, obviously, intermod was a big issue or is still a big issue on the 700 interoperability proceeding. And I know that QUALCOMM, for example, had some comments saying that with 25 dB of isolation, they thought the reverse intermod problem could be controlled.

And so I think like we will continue to go around to everybody that wants to comment. But still what I would like you to focus on is how -- if you have a thought on how many dB you might need for these various cases (A) and (B) to Sumit's point is that achievable?

One of the things we noticed about the first plan, to Steve's point, if you have a given -- if you know your duplex spacing and your concern is the mobile interfering combining with the TV while it is trying to transmit and receive, then you know where the intermod has to be.

And in the first plan, the duplex spacing is 90 MHz. So the TV has to be 45 MHz below to transmit and I think we are going to hear later a lot of people telling us that the filters are only 25 MHz wide, so it seems that the interferers would often be well outside the filter.

And so that's something I want to understand a little bit better is -- and that's very different to Steve's point in like a down from 51 plan. If you do try to put TV in duplex gap, the spacing is much smaller and maybe the case is very different there. I haven't thought about that one as much, but so just as we continue to go around, think about these things. I think Doug Hyslop had the next card up. So you need to keep -- you keep putting it up and down. You want to go next?

MS. TANDON: Yes.

MODERATOR HELZER: Okay. Neeti and then Doug.

MS. TANDON: So to echo David's point, you know, it all depends upon the signal level of the jammer. And to your question, is how much attenuation is needed, it again depends on what is the signal that is being received by the UE.

And in our experience, you know, in 700 MHz is that when you have a megawatt TV station, the signal level on the ground is very, very high. It is quite high.

And to the point, you know, on the rejection by the duplexer, it's a very valid point. You know, you have to take the rejection by the duplexer into consideration, but what about the front end? I mean, we are concerned about interference on the tuner, on the antenna switch and on the RF elements that come even before the duplexer comes into play. So that is another important consideration to be made in the intermod interference analysis.

MODERATOR HELZER: Okay. All right, thank you. Doug, I see you have your card up.

MR. HYSLOP: Thank you, yes. Doug Hyslop with CCA. When we talk about intermodulation, as you mentioned, Chris, there are really two pieces that need to exist. One is enough power needs to be present in the two signals that would mix and then the other piece of it has to be the intermodulation that is created would need to fall on a receive channel to cause interference.

And what we are seeing, as you mentioned, we expect the pass band on the duplexer to be 25 to 30 MHz. If you are employing a channel up near 51, it would have to be a midpoint down in the lower range of the DTV channels that would be left that would cause a mixture that could present an intermodulation that would hit on the receive channel.

But that DTV channel, given the great separation from the pass down to the duplexer is going to be attenuated. We don't see a concern with some of the other components ahead of the duplexer or we are not hearing about reports on the market today. I mean, there are lower 700 systems that have been deployed.

There are active DTV stations in 51 and 50 and 49, that's a very analogous situation. If there was intermod being generated from those types of situations, I think we would be hearing more about that.

MODERATOR HELZER: Okay. Thank you. I think Prakash's card has been up for quite a while, so if we could go to Prakash?

MR. MOORUT: Yes, thanks, Chris. I'm Prakash Moorut from Nokia Siemens Networks. I guess, you know, I think I would, you know, echo whatever all the other panelists have said before me.

I guess I have a question for the device manufacturers here. I mean, we have right now a problem between the Band 17 and Band 4 inside the same device when you do carrier aggregation. And so what 3GPP has come up with is, you know, 10 dB desense on the Band 4 receiver whenever band 17 is transmitting.

So I guess my question is how does that compare to some of the issues, you know, we are discussing right now because this particular problem occurs, you know, inside the device and it's quite severe.

You know, I agree about the 10 dB desense just might not be the ideal solution, but I guess my question is, you know, can these problems be, you know, solved?

MODERATOR PETERS: I think you had your card up.

MR. VERMA: Yes. I also wanted to just finish up or at least touch on the previous discussion. I was just looking through my notes here. I don't believe we ever said that 25 dB would be enough. In fact, I'm not sure we can make this point strong enough.

A TV inside the duplex gap itself would be, I think, almost, I don't want to use the word impossible, because I think as someone said earlier that's -- all that really means is it's not practically feasible, but it would pose a real serious technical challenge from a practical perspective.

There may be some places to hide a TV channel, but it would certainly not be in the duplex gap. I think we can say that safely. 25 dB would be nowhere near what was needed. The only possibility might be inside the uplink of the band plan itself and that is only if the TV is located physically below in frequency to the

LTE signal or sorry, whatever technology would be deployed.

And so those kind of details are very important. And so I did want to make it clear that we don't believe it is really practically feasible to have TV in the duplex gap.

MODERATOR HELZER: Well, I guess to be honest, I don't quite follow the line of argument. I mean, clearly the TV station, if it combines, creates an intermod, but I don't see what is magical about being inside the duplex gap or say below the duplex gap. You know, a TV station anywhere has the potential to combine.

And in all cases, you need to filter. I mean, generally, you need to receive filters. Actually, there is an Ericsson plan on the record for TDD that has no receive filter, but has pretty large guard bands. But in general, you need a filter and you need to attenuate it.

And I don't -- I understand the argument that maybe you need a fair amount of guard band on the sides of the duplex gap, but

I don't understand the argument that it is just not possible to attenuate something in the duplex gap.

So I just don't think I'm quite following your argument.

MR. VERMA: Sure. I think just to kind of give an order of magnitude to the issue, I think we were assuming something on the order of 50 dB of attenuation and even then it was kind of pretty marginal for the LNA, which is going to have the lowest -- the worst IP3 of all the components.

And, of course, a duplexer happens to be sort of already designed to have a large isolation in the downlink and the uplink band, which is why I was suggesting that. But even then, we are not saying it will work, just that seems to be if you had to put it, that would potentially be the safest spot.

MODERATOR PETERS: Why don't we hear from Victor?

MR. TAWIL: I'm going to try to talk

about intermod, but I'm going to talk about intermod from the other side, that's something which has been ignored over here.

As you know, we have a television receiver. The television receiver has been characterized very well in the past by the Commission in 2007. The issue here is we know what the intermod, third-order intermod products are.

And the concern here in this band plan or the 51 to 36 is if you have two downlink stations separated by N+2 or whatever, N is 5 MHz or 6 MHz and you have two stations trying to make some consistency. It falls into, what I call, the split band plan which is the 37 and above. That is a concern to a receiver.

Now, we in the television service, we usually aggregate these by having one high power transmitter or two in the market. In a situation now in the wireless industry have, you might have within a service area of a television station about 40 or 50 transmitters operating.

Combining those two, an intermod product, those two will affect our receiver. That's why we really do not like the split band plan. That is a major concern.

And all the discussion here has been centered on the other side, but you also have to look at this side of the equation. Thank you.

MODERATOR PETERS: Great point. Thank you. I believe, Brian, you were next. And if I could remind everybody to introduce themselves before they start speaking. Thank you.

MR. MARKWALTER: Okay. I'm Brian Markwalter with CEA. And I was going to raise the same point that Victor just raised, which is there is -- we also have to think about TV receivers. And in our comments, our belief is it is going to be very hard to do reception of TV signals when you have wireless broadband on both sides.

So I mean, Victor stated it well, but we also need to think about that case. The things we are talking about, as if they are interferers are also the signal that the TV receivers are trying to receive among these other signals.

MODERATOR PETERS: Let's go to Sanyogita, please.

MS. SHAMSUNDER: Sanyogita Shamsunder, Verizon. Going back to the comments that Sumit made and maybe your question on TV stations and the duplex gap.

MODERATOR PETERS: Can you get closer to the microphone, please?

MS. SHAMSUNDER: Sure. Is that better? Okay. So you can. I mean, like Chris you mentioned you can put a TV station, but then you will need guard bands around it to get enough rejection in the duplexer.

So at that point, you are ending up increasing the duplex gap, right? And there are associated issues as, you know, a domino effect of that that will quickly end up into broader antenna bandwidth requirements and so on. So by solving one problem, we are trying -- you know, we are creating other problems downstream in the design of the device, that's our analysis.

MODERATOR PETERS: Okay. Thank you. Harold?

MR. FELD: Yes. I mean, just a few points on this TV interference issue, which I think is important, which are -- and I'm Harold Feld with Public Knowledge, by the way. Sorry.

But first of all, I would point out we have now some experience of this in the 700 MHz band and we have some ability to evaluate the nature and extent of the -- of some of these interference issues and there seems to be a good deal of consensus around the fact that we were very overprotective in some ways with regard to the potential for interference between the 700 MHz A Licensees and existing neighboring television stations.

We have dealt with this to some degree also in the white spaces area where we have addressed these questions and had to ask the critical question of what level of weakness are we protecting? And an assumption around an existing television station.

The -- if we are going to protect television broadcast in the worst case scenario and then the hidden node problem and go through all of that, again, you are going to need enormous guard band between the broadcast -- the remaining broadcast service and the 600 MHz service regardless of how much spectrum you are going to reclaim.

MODERATOR PETERS: Okay. Christian, did you want to --

MR. BERGLJUNG: Yes, thanks, Tom.

MODERATOR PETERS: All right.

MR. BERGLJUNG: Just a comment on this -- on the problem of intermodulation and duplexer rejection. At least under an FDD Band Plan, of course, the duplexer filters, they have certain regions where they provide large stop band rejection.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: And for example, if

we look at the NPRM Plan, there are certainly parts in the duplex gap where you could locate a TV station and still get good intermodulation rejection.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: However, the entire auction process is based on fungible blocks and that means that some blocks in the uplink may be less favorable in terms of intermodulation. And, of course, we can all discuss probably for a day or so what is the risk of intermodulation, etcetera, because it depends on how you make your simulations or measurements.

But to us, the best way would still be to make sure that the blocks are actually fungible to, as much as possible, if not at all, avoid the problem of having TV stations in the duplex gap.

MODERATOR PETERS: Yes. I guess to that point, you know, we have some actual information to draw upon from the 700 MHz Band and maybe one way to steer the conversation is to say, you know, at 700 MHz, we have, you know, some of the Channel 51s are 1 megawatt.

There is a 6 MHz essentially guard band between Band 17 and these stations. And the resulting received product could fall on the Band 17 receive band. So I guess there are two questions there. One is, you know, is that an issue for AT&T and their operations in Band 17? And Neeti, I guess that would be a question for you, if you are able to comment on that.

But the second question is if it isn't an issue or even if it is, what are the potential differences between that scenario and what we might see in the 600 MHz Band? Neeti, are you able to comment on that?

MS. TANDON: Yes. I mean, there is enough comments from AT&T in the proceedings with regards to Band 17 and we also submitted test data that shows exactly what the problem is, you know, with regards to intermodulation and with regards to TV broadcast and coexistence.

And I said earlier, 1 megawatt TV

station when you are combining two incompatible systems, you know, coexistence issues between two incompatible systems is something not very easy to design a network to.

MODERATOR PETERS: Yes.

MS. TANDON: And so that is already in the record. And as to what is the difference -- and that's why you know what as AT&T, our comments are so much focused on the interference issues is because we have experience with them.

MODERATOR PETERS: Yes.

MS. TANDON: And that's what we are trying to say. And the fungibility of the blocks, like what Ericsson put in, is very important to us. So in order to avoid this Band 17 and Band 12 and all the interoperability issues that are associated with it and also for international harmonization.

I mean, you and I have worked with Mexico, right? And so you do want a band plan that is fungible and that is easy to adopt, especially at the regional level.

MODERATOR PETERS: I guess, I mean, one of the points is that the situation of Band 17 is only 6 MHz separation as Chris was describing. Perhaps in some of the band plans proposed for 600 MHz there would be even greater separation, even more room for the filters to roll off, resulting in greater attenuations.

So with that, I think, Doug, you had your card up?

MR. HYSLOP: Yes, thank you. Just wanted to jump in on 700 MHz intermodulation. There is a couple of test reports in the record as well showing that commercial devices, the performance they have tested in the lab, and in field measurements in multiple markets as well, do indicate that there is not an intermodulation issue in the lower 700 MHz Band and the lower A Block Licensees are very much interested in coming to closure on interoperability.

MODERATOR PETERS: Yes, okay. Thank you, Doug. Delroy, you had your card up. Please.

MR. SMITH: Delroy Smith, Philips Healthcare, a Physical Scientist. So I represent the wireless medical telemetry solutions from Philips. We have like 46,000 devices deployed throughout the United States in hospitals. These have been in hospitals for, you know, 10 years or more.

You know, we have designed systems to work with the high powered TV stations. In the top band plan, you know, you describe that there is no guard band. And, in fact, what really happens is that there is a guard band, but it is inside of the Channel 37.

So what happens whenever we have to work with a big TV station, we lose about 80 -- 20 percent of the spectrum. Now, as you start to repack more TV stations into new regions, I think one concern is that some may -- have already built out their systems and are utilizing all of that spectrum and now they would be faced with the prospect of having to lose some of that spectrum just to work with a nearby TV station and so forth.

You know, we -- you know, in today's marketplace there were much -- there were sort of fewer TV stations to work with. In some markets, there were never -- there weren't any stations. And so we were able to sort of build out and provide hospitals with full service that we wanted and so forth. So that's something to consider as you look at the band plan.

When I look at the second plan, down from 51, that looks more attractive to us. As -- although, there may be more base stations around, they would be lower power and we can -- our systems would really work, I think, quite well in that scenario without impacting and losing capacity in hospitals and so forth, you know.

And so that's one point I wish to just bring forward there. Thank you.

MODERATOR PETERS: Okay. Thank you very much. I want to spend a few more minutes on this topic before we move on to harmonics.

And, David, I know you had your card up, but let me read a question from the audience and also reminds the folks in the audience and viewing on the web that you are welcome to submit questions and we will try to get to as many of them as we can.

So this question, basically, says intermodulation interference is a location dependent phenomena in areas that are near a powerful transmitter or not -- are affected, but areas that are far from such transmitters are not.

In other words, I think he is saying that the issue is only in an isolated area close to the TV transmitter. So how does this fact affect the seriousness of the problem? We will hear from David and if anyone wants to respond to that, feel free as well.

MR. STEER: So you had asked -- maybe two sort of points just to follow-on. You had asked what is the difference between the existing Channel 51 and the 700 MHz. Of course, what that brought to my head is the issue about antennas. And I realize this isn't necessarily the section to talk about antennas, but one of the differences is in the 700 MHz, at the moment, our antennas are really bad at 600 MHz.

They are not so good at 700 MHz either. But -- and so that is providing some protection against Channel 51 in our equipment or at least in the handsets, which would not be there in the case if we are working at the 600 MHz as well.

Our product guys tell us we can only get one antenna in the device, so it's going to have to go from 800 down to 600 and it is going to be a really fancy thing, but we can't get two of those in there. And so that means the antenna will open up and you will have some effects from that.

The other -- Sumit mentioned 50 dB. We had some numbers like that in some of the things that we looked at, whether that is path loss or whether we put it in with filters, it's better if we do it both places those kinds of numbers. And that's a big number to have in a filter. It's even a big number in a path loss case where it is line-of-sight as well. Thanks.

MODERATOR PETERS: Yes. One of the complexities is that a lot of these issues are interrelated, the topics that we are going to discuss today. So, Christian, please.

MR. BERGLJUNG: Yes, thanks, Tom. Coming back to that question, yes, of course, the problem may be more serious close to your TV station. And it is also a function of your own wanted signal level, of course, on your base station deployment close to that TV transmitter.

And we -- on assessing the risk of interference, that would be a quite complex task to do it. And I think we could probably spend the entire day here looking at just that particular aspect. We would like to make a simulation with a full deployment in a network.

But we would like to come back to this risk of interference in relation to the fungibility of the spectrum. And in our viewpoint, we think it is still best to avoid this problem altogether by devising a band plan that avoids intermodulation interference in the duplex gap.

And then touching briefly upon the Channel 51, we -- in the 3GPP standardization where these bands were specified, we also looked at the potential reverse intermodulation that you can get in relation to other phenomena.

And one thing you need to bear in mind also is that the TV interferer that is below the -- your own uplink channel in relation to your received bands. So that's also a different scenario than the one we are considering here where the interferer is between your uplink and downlink channels.

So there is also a slight difference. And in the 3GPP proceedings, we also looked at the possibility of protecting the broadcast, of course, which is another problem that we should also consider when devising the necessary guard band.

MODERATOR PETERS: Okay. Doug, I think you wanted to -- why don't you take the last word and we will move on to the next topic when you are finished.

MR. HYSLOP: Thank you. Yes, I did want to mention we certainly should have duplexer performance come into the equation. My understanding of the background of that is the roll-off in the direction of your receive band is generally better than the back side of the duplexer going away from it.

But then the separate issue as well, getting back to the question of power, as we think about DTV transmit powers, you know, the power at the antenna really doesn't matter, the broadcast antenna. What matters is the level on the ground.

And so that is a consideration as you have, you know, the higher the power on the DTV transmitter, then generally the higher above the terrain you are. You need to look at the power levels on the ground and those are all relatively similar among different broadcast stations and they are not that different from what you see from an LTE base station, if you happen to be very close to it.

MODERATOR PETERS: William, I saw an expression of disagreement on your face, I think. Do you want to explain before we move on?

MR. MUELLER: Okay. Does this sound okay? William Mueller with Avago. We make filters and duplexers.

So it may help to put some numbers out on what is possible in the filters and describe a little bit what a filter looks like, because the mental images -- you have a pass band where everything is perfect, the rest outside of that where everything is cutoff and, unfortunately, that's not the case. It has variable rejection over parts of the band.

MODERATOR PETERS: Yes.

MR. MUELLER: So if you look at the pass band, the pass band actually has to be wider than the spectrum you are going to support because of temperature effects on the duplexer. It is important to understand when we are looking at the Channel 51 700 MHz case that the TX Filter that you are looking at there is actually not rejecting 51 at all.

It is -- that's part of the pass band that you are within as you slide the filter back and forth. So that's a different circumstance than you are likely to have when you have a guard band and then a rejection to TV and the channel. So it may not be too relevant, that's just a comment there.

The intrinsic floor of the duplexer is variable with the duplexer design. In modern duplexers it is around 30 dB. Maybe you can push it to 40. It would always be at least 25, I would think. So if you are not trying and you get away from the guard band, you get for free some, you know, 20, 25 dB of rejection. There may be exceptions to that, but that's generally the rule.

The place you concentrate on the design is to get rejection for self-desense in the receive band. There you’re after numbers in the 50 to 60 dB. You only get those if you try and do them. So if you need 50 to protect yourself from TV stations, then you are asking for a very wide deep reject and that's a very difficult filter to design.

So maybe those numbers help understand the capability and where things can go. Relative to the comment about steepness on one side or the other, that's the design capability. It is true of most of the duplexers deployed, but there is nothing intrinsic about that.

So you can make that be whatever shape you want it. That's just purely up to design. So hopefully that helps.

MODERATOR PETERS: Yes, very helpful. Thank you very much. I think we will move on to the second issue on our list of interference issues and that is harmonics.

Harmonics. This is a case where there is a third harmonic from the 600 MHz band or parts of it, so 3 x 600 is around 1,800 and lands in the PCS receive band. Similarly, at 700, 3 x 700 is around 2,100 and lands in the AWS receive band, which I think Christian alluded to earlier. So one of the-- Prakash. I'm sorry.

So the question then on this issue of harmonics which has been brought up in the record, what exactly is the problem? How is it different than the problem at 700, if it is different. And what can we do to remedy it? Does anybody want to comment on that? Thank you. William?

MR. MUELLER: It was left up, but actually I can comment a little bit at least--

MODERATOR PETERS: Okay.

MR. MUELLER: -- perhaps. So the issue in the 700 MHz in the harmonics tends to be one where your harmonic hits one of your receive bands that it is on, which is usually a carrier aggregation scenario.

And what is the issue there is you have a relatively high power coming out your transmitter, which is hitting the front end components. And the comment was made earlier about the linearity of those and the distortion created in them, that's usually the limit.

Because if you are in a case where you are far from the base station, you are broadcasting at full power and trying to detect a very weak signal. And so it doesn't take a very strong signal in your receive band to make things difficult.

That's fairly different from an external TV signal that is down at a much lower level. If you are talking about -40, which is a number I heard earlier on the ground, compared to +30 going out the antenna, well, +20 by the time it gets to the antenna, but +30 out of the PA roughly --

MODERATOR PETERS: Yes.

MR. MUELLER: Those are quite different circumstances. So if it helps, the intercept point of most of the front end components, switches or filters, is around +70 dBm. And that means you will get some intermod created if you have these 30-ish signals and you are looking for a -115 or so on the receiver.

MODERATOR PETERS: Okay. Christian?

MR. BERGLJUNG: Yes. Definitely harmonics is a problem that we have had to deal with before. And already in today's 3GPP specifications for the bands where you have to protect other UEs, you are looking for one UE to another UE. We already allow exceptions for harmonics falling into other receive bands, not to over-complicate the design of the UE.

That may still make that spectrum very valuable, but we do leave some alleviation for the UE designer. The particular Band 17 -- sorry, that's the 700 MHz band, the Band 17. The Band 4 problem that we were talking about earlier, for that in the specification, the particular problem as William mentioned is that

that's in simultaneous operation between Band 17 and Band 4, so that you receive a harmonic in your receive band.

And in the specification, we did allow about 10 dB desense or 10 dB degradation of your reference sensitivity as a balance between acceptable performance and the penalty on the UE design. So that still assumes that you have some kind of rejection of your harmonic component being able to meet that particular requirement.

So it's a balance between the acceptable performance and the penalty on your design.

MODERATOR PETERS: Okay. Oh, sorry, Sumit, please.

MR. VERMA: Yes. Just a couple of points that I wanted to clarify. One, I'm not sure if it was clearly mentioned, but the primary issue here is carrier aggregation and not, for instance, meeting emissions which generally would probably need to meet a requirement on the order of -30 dBm per MHz or so.

And so that, meeting the emissions requirement would not be the challenge. I want to make that clear. The challenge is carrier aggregation and, obviously, there is already an example in 17+4 and 12+4 for that matter.

And in those cases, I just want to be clear, yes, we have standardized those combinations, but it is -- it wasn't that it was penalty free. And I think it was pointed out correctly just a minute ago that the standard has about 7.5 dB and 10 dB of performance degradation in Band 4 downlink.

So it is a very challenging problem when you have a harmonic that lands in the downlink band.

MODERATOR PETERS: Yes. One of the things that comes to mind is, you know, what I talked about at my introduction remarks about weightings and whether or not this is something that we should weight heavily given that, you know, there are a lot of other bands that one could aggregate with the 600 MHz Band, perhaps that don't have this harmonic issue.

Does anybody have any comments on how we should think about weighting this particular issue? Neeti, I'm sorry, so ahead.

MS. TANDON: Yes, I just wanted to add AT&T's experience on this Band 17 and Band 4.

MODERATOR PETERS: Of course.

MS. TANDON: And to the trade-off of the 7 to 10 dB that is not an elegant solution. You know what, we don't -- in fact, we are not even supporting uplink on Band 17. The uplink is on AWS, because 7 to 10 dB degradation is definitely not acceptable by the chipset manufacturers or the UE manufacturers coming from a network point of view.

So we looked at how harmonic filters and others and I'm looking for a solution to it, so --

MODERATOR PETERS: Okay. Thank you. David?

MR. STEER: Yes. So you asked, I guess, for some thought on how important say the trip, the third harmonics were compared to some of the intermod things.

MODERATOR PETERS: Yes.

MR. STEER: I think that was your question. And my observation was when we passed some of these questions by our designers, the intermod one was there. The other one was. They deal with that all the time. There probably is some magic that they can fix that if you don't choose any really bad cases.

And so I think the thought is that maybe it is less important than some of the other things we are going to talk about.

MODERATOR PETERS: Okay. Great. Thank you.

MR. STEER: At least from our perspective.

MODERATOR PETERS: Okay. Great. Thank you. Christian, did you want to?

MR. BERGLJUNG: Yes. Thanks, Tom.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: Maybe first to mention that this particular harmonics problem in relation to carrier aggregation is also an issue for all the Bands 12 and Band 4, so both of these combinations have been specified by the 3GPP.

But one thing that perhaps the FCC could do with this, bearing in mind that some combinations may be problematic for carrier aggregation, would be, for the FCC really to make the blocks fungible, to look at the winning company, the winning bidders and their spectrum holdings and to allocate the block so as to avoid harmonics problems if the bands are combined with carrier aggregation.

So that could be one way of addressing this problem and to avoid cases where you would have to accept 10 dB degradation.

The 3GPP specifications do specify minimum requirements. So this 10 dB degradation is a minimum requirement. You are, of course, allowed to beat this requirement. And that's what we are all trying to do.

MODERATOR PETERS: Thank you. That's an interesting suggestion. Rick, I think you were next.

MR. ENGELMAN: Thank you, Tom. Rick Engelman with Sprint. In response to the question on the importance of this, I think we agree with David that relatively speaking, this is not so important. I think part of the problem is when you look at carrier aggregation is, it really is dependent upon the vision of who the licensee is and this goes back to what Christian said.

But I think those visions change with time and they change as new bands become available and it is very difficult to predict today in a rulemaking proceeding where people will be thinking on carrier aggregation down the road.

I think the concern we would have is it's very important this is a limited amount of spectrum. It is almost a once in a lifetime opportunity for carriers to get spectrum below a gigahertz.

MODERATOR PETERS: Yes.

MR. ENGELMAN: To the extent you allow harmonics to dominate and make the band plan relatively inefficient by trying to protect all the possible options, I think you really are doing -- undermining your goals for making this spectrum useful. And I think that would be our concern.

So Christian is right. The 3GPP -- the standards process is a way to develop specs that people can understand and meet for these kinds of things and then the operators make their decisions based on those specs and based on what is available, but I think this is not, in our mind, something that should dominate the band plan discussion.

MODERATOR PETERS: Great. Thank you. Darryl?

MR. DeGRUY: Yes, I just wanted to

comment on a comment that Christian made about the -- looking at what spectrum holdings a carrier or licensee might have.

MODERATOR PETERS: Yes.

MR. DeGRUY: I do want to just emphasize that that changes over time.

MODERATOR PETERS: Yes.

MR. DeGRUY: There are subsequent trading of spectrum that changes that picture going forward. While I point that out, I agree with what was just said, harmonics shouldn't be the top of the list because carriers can design their network, much as AT&T just described, to try and avoid these situations by putting the uplink channel assignment in a certain allocation to try and avoid that harmonic.

While that does cost some network performance and does, you know, bring down the overall network capacity, it is a way to avoid the harmonic situation for carrier aggregation specifically.

MODERATOR PETERS: Yes, understood.

MR. DeGRUY: Thank you.

MODERATOR PETERS: Thank you. Sumit, I think you are next.

MR. VERMA: Just a couple of points. You know, as an equipment provider we, of course, have to make sure that, you know, the spectrum can work for everyone. And the fungibility of the blocks, I think, is probably the main concern here.

Lastly, I think we talked about B2, but really the B2, B25 and B41, there is a fourth harmonic that would fall in in B41 as well, and so, you know, there -- for the blocks where the harmonics don't fall versus the blocks that -- where the harmonics do fall, one could argue there is a difference in value and that would affect fungibility.

And so sorry, the last thing I wanted to say is -- no, sorry, that's it. Thank you.

MODERATOR PETERS: All right. Got it. Sanyogita, for the last word on harmonics.

MS. SHAMSUNDER: Yes. Well, I guess

so, but we have the second harmonic problem in the 700 MHz as you pointed out. And we solved it with the harmonic filter, but I agree perhaps that it is not one of the top issues to consider, but it is an issue here. Not just from a carrier aggregation perspective, but even GNSS.

I mean, the harmonic falls in GNSS, so it's not just carrier aggregation. It's a -- it will be a problem for everybody, not just specific carriers.

MODERATOR PETERS: Okay. Thank you very much. I assume, Rick, that you -- did you want to comment? Okay. Thank you.

Quantity. So with that, I think it's time to move on to the third issue, which is related to the market variation that Chris was talking about and the desire, one of the goals that Ruth stated in her opening remarks was quantity and avoiding this least common denominator issue, but ultimately, that results in pieces of the band, regardless of the band plan that ultimately gets chosen, pieces of the band would need to be used for mobile broadband in some areas and for DTV in other geographies.

And that results in an issue where neighboring markets, you know, have different services in the same swath of spectrum. Now, if we unpack this a little bit and look at the various scenarios, there is one in which the DTV and the FDD uplink are co-channel with one another or assigned to the same frequencies.

And in that case, you would have an issue with DTV stations potentially causing interference to mobile broadband base stations because both are above the clutter. And you would need to have some separation in place in order to avoid that type of interference.

We understand that. But we want to get some comments on what that is, but, before we get to that, I'll mention the other case, which is it is possible for some band plans to have the opposite in which, I'll call it, supplemental downlink, for example, could be used in some areas and TV in other areas.

So this is a case where the downlink of the FDD is co-channel with the TV. And in this case, you have really two problems. You have the case where mobile broadband base stations might be causing interference to DTV receivers. And you have the other -- the complementary case where the DTV transmitter might cause interference to mobile broadband UEs, devices that would typically be below the clutter.

But let's hear from whoever would like to comment on these issues. What's the worst case? What should we be thinking about in terms of designing a band plan? Is it better to have co-channel with uplink or with downlink or with neither? And how much separation is needed?

Let's hear from Jay, please.

MR. ADRICK: First of all, Jay Adrick with Harris Broadcast, not Harris Corporation.

MODERATOR PETERS: Right.

MR. ADRICK: We are entirely separated from Harris Corporation. I'm going to try to put some real-world experiences before the group.

I have access to a vacation facility up in northern Ohio, the northwestern corner of the state, and we have a typical home reception, small Yagi-type antenna designed for a 50 mile reception. Normally, we watch the Toledo and Detroit markets, sometimes the Cleveland markets.

At various times of the year with great consistency and with long periods of viewability, I can watch stations out of Rochester, New York, Channels 45, 28 and 16, so we pretty much span the gamut of the 600 MHz Band.

Being an inquisitive-type, I drug a spectrum analyzer up and hooked it up to the antenna to try to see what level of signals we were looking at. And being very familiar with the ATSC standard, the theoretical threshold of the ATSC standard is about -82 dBm.

And I have witnessed signals that peak on the order of roughly 25 dB greater than threshold for long consistent periods of time. We're talking 8 to 10 hours of the day when you could watch those stations.

Usually in the fall it is ducting and it occurs generally when you have got bodies of water, in this case, Lake Erie and Lake Ontario, but we all know that when the DTV transition occurred, there were a number of cases of co-channel interference on the east coast where we had ducting north to south and vice versa.

So one size in terms of separation will not fit all. It is going to be a situation where various parts of the country are going to be subject to regular occurrences where co-channel interference could occur.

And again, I don't know what the threshold is on either the base stations or the portable devices for the wireless industry, but I would have to believe that they are lower signal levels than what the ATSC television receiver has.

MODERATOR PETERS: Just out of

curiosity, can I ask what's the height of the Yagi that you have?

MR. ADRICK: Rooftop on a single story house with a small tripod, so on the order of 25 feet.

MODERATOR PETERS: Okay.

MR. ADRICK: No pre-amp.

MODERATOR PETERS: Yes. Interesting. Thank you. Prakash?

MR. MOORUT: Yes, I haven't done-- you know, I haven't put out a spectrum analyzer, but you just -- we have been through that process in Europe. CPT one of the defining their, you know, digital dividend time and they have done some studies, you know, simulation-based.

And I agree that, you know, you cannot have one distance, for example, that could treat all the scenarios, but some of the distances were coming way forward in terms of the TV and the base station receive were like 200 kilometer. You know, just to give you, you know, a number.

And they -- by looking at other mitigation factors like antenna directivity and interference consolidation, they were able to bring this down to 50 kilometer. I think, you know, but again, I think, you know, we can question those numbers. I think the 200 kilometers is a good starting point. It could be, you know, a problem when you have those broadcasters and the base station receiving on the same channel.

MODERATOR PETERS: Thank you. That brings up another question for Jay, which is how far is Rochester from the place in Ohio?

MR. ADRICK: 334 miles separation.

MODERATOR PETERS: 334 miles.

MR. ADRICK: From the house to the transmitter.

MODERATOR PETERS: So about 500 kilometers.

MR. ADRICK: Correct.

MODERATOR PETERS: So then, in your opinion, Prakash's estimates are maybe low?

MR. ADRICK: I would say they are very low.

MODERATOR PETERS: Okay.

MR. ADRICK: Particularly for certain parts of the world --

MR. MOORUT: Yes, I think it was. Yes, it was --

MR. ADRICK: -- of the territory.

MR. MOORUT: Yes, for at least 200. I think, yes, it went up to, you know, probably 400, 500 kilometers, just to give you a range. I mean, the minimum was 200.

MODERATOR PETERS: Victor?

MR. TAWIL: Yes. Again, I feel like an orphan child here, but I want to point out the other side of this, which also you talked about co-channel interference. And if you do a variable market plan, there is always a possibility that the mobile device will be operating inside the service area of an adjacent market, if you assign it that way.

So there is also a protection that

has to be considered for the service area of that television station in a variable market situation, you also pointed that out.

And that is -- basically, you know, it has been well-established in your existing rule in 27.60, which if you are operating a mobile device, you have to be outside the TV service area. That was precluded from the proceeding at the time.

We made some comments on that. So there are two sides. There is the interference to the base station. There is also in a variable plan, which we do not -- and a variable market-by-market variation. That's another consideration you have to do for interference to television as well as interference to the base receive side and the downlink as well. Thank you.

MODERATOR PETERS: Thank you. Christian?

MR. BERGLJUNG: Yes, thanks. For the interference into the mobile systems from the base station uplink side, we, of course, do have some means of coordination, antenna tilting or changing the sectors, etcetera, that can be done.

For the UE side and the downlink, that often also depends on your wanted signal level. You would assume that that is a low level as you go into an adjacent market, if the UE roams into an adjacent market.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: In all these cases, to avoid these problems with the market-specific plans, we think the best thing would be to, as much as possible, get the nationwide plan, so that we can avoid this problem.

MODERATOR PETERS: So you are in favor of the least common denominator?

MR. BERGLJUNG: Yes.

MODERATOR PETERS: Okay. Let's hear from Darryl and then we will go back to Victor.

MR. DeGRUY: Yes, I just want to comment on the rules that were put in place, as was just described, to protect TV receivers. I think it was .60 if I remember correctly.

We have looked at some situations where and worked with TV broadcasters to try and find a compromise, I'll say, to that, because not being able to operate anywhere within the service contour might be a little bit overprotective, I'll say, in areas where you are on the potential fringe.

I won't speak to the ducting aspect, that's a different situation. But if you are out on the edges of that service contour of the TV station, the chances of getting a mobile in front of that Yagi antenna that is on top of the roof on a tripod becomes challenging.

If you are sitting in the living room with a UE or a mobile device right next to some rabbit ears or even a reflective dish-type antenna, then, of course, the interference situation is much different than the case that was described where the antenna is up on top of the roof out in the edges of a TV service contour.

MODERATOR PETERS: Yes, I agree. I would point out that propagation over Lake Erie is probably a special case relative to most of the country, but still an interesting case nonetheless. Victor, please.

MR. TAWIL: I have to comment on that. Again, it's actually where the most -- TV is the most vulnerable. At those distances, you have a high gain antenna that is at -- and you have the lowest signal level. So a mobile device operating at the edge of the service area is actually more problematic for us than operating closer in, because you-- it's a co-channel operation.

You have to meet the carrier-to-noise ratio and that's why the signal is the weakest. So actually it is the most vulnerable area in the service area. It's close to the edge.

MODERATOR HELZER: So I actually want to follow-up on that a little bit, because I'm not sure I fully understood what you are saying.

So to separate the two cases for a second, in the uplink case, as I think NAB has pointed out and Tom just mentioned, to, the interference to the broadband system is from a tower to a tower, so that's likely to result in the large separations we are hearing about, 200 kilometers.

I think in that case, given that the LTE station's service area is going to be much less than 200 kilometers, if it's limited to 100 kilometers in terms of timing, and practically usually far less than that, it seems like in that case the mobile should be not a big concern for the TV. And so I'm-- what I'm thinking that what you are saying is that it is the case where downlink and TV stations are assigned to the same channel that you are more concerned about. But that doesn't make sense either, because then the mobile is not transmitting.

So I'm a little confused. If you could just clarify?

MR. TAWIL: Let me explain that. I think we were addressing the market-to-market. We were not addressing the -- that situation.

And the market-to-market situation, when you have two channels removed and you allow a TV station in a variable plan to operation in Market A, two channels are moved and becomes a co-channel. And we are saying you've got to protect that co-channel operation.

So what we mean here is that if you have a TV channel in the middle and in Market A -- and we put that in our comments. Market A you actually assign -- assign it to broadband and then Market B you assign it to television.

And then so that Market A operating within that -- is allowed to operate within the service area of that two channel remove will -- that mobile device will impact the reception.

MODERATOR HELZER: Okay. So --

MR. TAWIL: It's the market. I think there are two issues.

MODERATOR HELZER: Yes, well, so I

think we are operating with -- I mean, I think with the assumption we are operating on and asking the questions on is if television is in a market --

MR. TAWIL: Yes.

MODERATOR HELZER: -- then, obviously, wireless broadband is not assigned in that market, but we think it has to be assigned some distance away.

MR. TAWIL: Yes.

MODERATOR HELZER: And that's the question. If the correct answer is 200 kilometers, then if television is in Market A, then Market B and Market C may just be unused, because Market D may be the closest that --

MR. TAWIL: The question is that--

MODERATOR HELZER: -- can play.

MR. TAWIL: -- the separation to protect broadcaster is less than the separation to protect base station. That is correct.

MODERATOR HELZER: Well, I'm assuming that the propagation -- in the uplink case, since the TV to the wireless broadband is tower-to-tower and the other one is handset-to-mobile, I'm assuming that that case is dominated by --

MR. TAWIL: Yes, that is correct.

MODERATOR HELZER: -- the tower.

MR. TAWIL: That is correct.

MODERATOR HELZER: Okay.

MR. TAWIL: But it becomes more transparent when you have a variable plan where the third -- the TV station in one market is assigned to operate a wireless network where in the same market, you have two channel remove. You allowed to do wireless, but not the TV station. So that's the issue.

MODERATOR HELZER: Thank you. Thank you.

MODERATOR PETERS: Great. Thank you very much. I want to make sure we have a little time left, about 10 minutes, to get to our fourth issue, which is the adjacency with Channel 37 of particular interest to medical telemetry.

Adjacency to Channel 37. And the question is in a case where the amount of spectrum that is repurposed is more than 84 MHz, we would then have to assign, assuming we are coming as these plans all do start at Channel 51 and work their way down in various ways, but, more than 84 MHz would put us on both sides of Channel 37.

And there is a number of ways to handle that. If you look, for example, at that second blue plan there, you have this possibility of having downlink on both sides of Channel 37. And one design consideration that I think isn't documented very well on the record is how do you handle that situation?

For example, if you were designing a duplexer for a band like that, would it be possible to have that duplexer include Channel 37 or would that create too much interference to the mobile device from other uses of Channel 37?

Does anyone on the panel have any thoughts on this particular issue? Is there-- oh, Prakash, go ahead.

MR. MOORUT: Yes, so, you know, I will let William comment on the feasibility. Let me put on the duplexer side, let me put out something here.

The 3GPP blocking spec for devices is, I think, -56 and -44 dBm, so I guess if the signal we are getting from this Channel 37 is lower than those numbers, you should be able to deal with that.

But again, you know, the question is, you know, what type of signal level you will receive from whatever is operating, you know, in Channel 37.

If there is higher interference levels coming, I mean, you know, you can have network planning. You can compensate by having a stronger wanted signal from a base station, but hopefully, you know, can solve the problem.

So I don't think it's a big problem, but, you know, let William contradict me or confirm what I say.

MODERATOR PETERS: Great. Thank

you. Christian?

MR. BERGLJUNG: Yes. Thank you, Tom. In our comments we provided those FDD alternative and the TDD alternative in the neighborhood of Channel 37. And we have looked at both interference from the services in Channel 37 into the mobile system and the interference from the mobile system into the Channel 37 services.

And we believe it is possible to allocate uplink transmission below Channel 37 if you make sure that there is a guard band between the uplink band and, for example, the wireless medical telemetry services in Channel 37. So that will be possible and in that way create more uplink/downlink spectrum either by a secondary FDD plan or a TDD arrangement below Channel 37, but even though the wireless medical services is secondary spectrum, we think it is very important to make sure that we do not interfere with the medical services in Channel 37.

MODERATOR PETERS: Right. From the

mobile uplink. And how much guard band did you determine was needed?

MR. BERGLJUNG: We looked at -- we looked for our FDD Plan, we looked at 6 MHz guard band. And thus also including Channel 37 in the duplex gap of that secondary FDD Plan. So then we would count on some filter roll-off, so that we have some attenuation within the Channel 37 for that plan.

MODERATOR PETERS: Just to clarify. That's 6 MHz all on the downside.

MR. BERGLJUNG: Yes, all on the downside.

MODERATOR PETERS: Right.

MR. BERGLJUNG: Yes.

MODERATOR PETERS: Okay. Thank you.

MODERATOR HELZER: Essentially 36 and 37 would be the duplex in the plan.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: Right.

MODERATOR PETERS: David?

MR. STEER: So you had asked about the option for if it was downlink on both sides of Channel 37. So we need to have some brief thoughts on that. And it seemed to me that it was okay for us to have our duplexer open up to that gap.

We don't have radio astronomy receivers in our handsets. And the signal levels that are, from the medical devices, low enough where there wouldn't be generally an issue.

In thinking about that some more and having been a radio astronomer in my younger days, I did worry a bit about the allocation of the downlink transmitters in relation to radio astronomy then. And I know in some places there are some restrictions on the sighting and the power of the TV stations that are adjacent to Channel 37.

And in that scenario, I guess speaking as a radio astronomer, one would hope that that practice would continue to protect their receivers. Thank you.

MODERATOR PETERS: Great. Thank you. William?

MR. MUELLER: So just to speak to the filtering capability here, if you want the duplexer to pass the frequencies on the other side, obviously, you are not providing any filtering help for 37, so you are vulnerable for whatever power levels there are.

The person on my left is saying their study showed it wasn't a problem. The person on my right is showing indications that it might be. So I don't know what the answer is on that. But filtering isn't going to help you. You are going to have to do it with power control somehow.

If you want to try and do it with filtering, then you need some guard bands. And the guard bands are going to take up, I don't know, 6 to 8 MHz from there to wherever you receive your downlink is, whichever side it is. That's just the way the UE is going to have to work. So there is not too much you can do about that in the filters.

MODERATOR PETERS: Great. Thank you very much. Sumit?

MR. VERMA: Just a couple of points. When is that -- the primary issue here will be inside hospitals where there will be mutual interference and probably the UE would have to use a different band in those scenarios.

Another point to make is that having downlink closer to Channel 37 would actually be helpful, at least you only have the interference going one direction.

And sort of the last thing to sort of point out is Channel 37 being where it is, and a lot of the band plans can actually serve as a useful part of the guard band that would eventually be needed between the downlink and any high powered TV that may be remaining below Channel 37. And so it kind of serves that potential useful purpose as well. Thank you.

MODERATOR PETERS: So we are talking a couple of different things. When downlink is adjacent to 37 versus when uplink is. One of the suggestions or possible remedies to the uplink issue, you know, as William pointed out, filters might not help you there without significant guard band.

But you know, how much would co-location with, you know, ensuring that the mobile broadband signal was strong enough, so that mobiles would be transmitting at very low power in those situations, if that could be helpful. But I just throw that out as a suggestion then. And, Sanyogita, please.

MS. SHAMSUNDER: Yes. So I am answering the question directly whether you can do -- you know, put 37, Channel 37 in the duplex gap. I think overall it is better if you have the entire uplink and downlink to the right of 37 and use 37 for -- to help as a guard band and downlink.

That -- I know this is a mixture of topics. We are going to talk about antennas next, but it, essentially, mitigates some of the other issues.

MODERATOR HELZER: Yes, I know. I think our concern is just, you know, if the auction results are repurposing a lot of spectrum, more than 84 MHz, you would still want to go past 37 in some way.

And so the question is in that scenario, what's the best way to deal with 37 being there? I think is really kind of the focus. And, Christian, you just put your card up while I was saying that, so I don't know if you have a thought?

MR. BERGLJUNG: Yes. It's certainly viable to run downlinks on either side of Channel 37. And in that case, you could reduce the guard bands that will be allocated towards the Band 37. At least for some of the larger base stations, if you are talking about pico base stations, you might not have the same filtering capability and they may also be operated in the vicinity of these devices, medical devices in Channel 37.

However, we do recognize that if we

allocate uplink spectrum, we need an additional guard that is larger than like 3 MHz. We need some 6 MHz guard to make sure that the TX Duplexer can roll-off sufficiently to protect the Band 37 under most circumstances.

MODERATOR PETERS: Okay. Great. Victor, you have your card up. Was that -- did you want --

MR. TAWIL: Oh, no.

MODERATOR PETERS: Okay. Just wanted to make sure. We'll get that. No worries.

So it's going on 11:15 and I believe we have exhausted our subject matter for this particular topic. And so we are going to take a short break and reconvene at 11:30 to talk about antennas. Thank you all very much.

(Whereupon, at 11:15 a.m. a recess was taken until 11:32 a.m.)

MS. SULHOFF: So while we are waiting for one or two more of the panelists to make their way forward, I just want to remind everybody if you have questions, please, submit them as soon as you think of them.

Those watching remotely who may have just joined, you can submit a question by sending an email to livequestions@fcc.gov. Please, include your name and the company you are affiliated with along with your question.

And again, if you are sitting here, we have some notecards and pencils, I think, not pens today, which you can submit your questions as well.

So I think we are ready to get started.

MODERATOR PETERS: Thank you, Cecilia. Somebody mentioned to me during the break that although we seated you by -- in alphabetical order by company name, that the broadcasters are sitting in the duplex gap, so apparently it does work.

Next we are going to switch topics and talk about antennas. Obviously, as we go lower in frequency, antennas are inversely proportional. The size of antennas are inversely proportional to frequency, proportional to bandwidth and antenna design challenges become more prevalent at lower frequencies.

We certainly have that situation here. On top of that, various band plans present additional potential challenges to the antenna design and the subject of this next session is to explore those challenges a little more deeply.

So let me start things off by asking the general question, if someone would like to comment on what are the key challenges to antenna design for this particular 600 MHz Band as it relates to a mobile device? Does anybody want to start us off on that? Christian?

MR. BERGLJUNG: Yes, thank you, Tom. It is, of course, inevitable as we go down in frequency and considering a fixed device size that the antenna performance will be more difficult to maintain.

We still think that this presents a

very big opportunity for the FCC to allocate spectrum for mobile according to the National Broadband Plan, so we should make all our efforts to make sure that this band can actually be implemented using a single antenna that promotes interoperability.

That does not, of course, preclude other antenna solutions that can also meet this. However, in this work, if we are, for example, looking at minimum performance requirements for an antenna, one needs to realize that comparing to the range 800 to 960 MHz or even going down to 700 MHz, if we stretch that down for receive and transmit to around 600 MHz, we would expect like a 4 dB penalty on efficiency, roughly.

And that is based on earlier DVB measurements earlier. The DVB goes down to 470 MHz, but that would be the constraints that we would experience -- that we expect to experience for both transmit and receive down to around 600 MHz.

Then, of course, we would also need

to realize that if -- as we make the bandwidth, total antenna bandwidth wider, that would also have an implication on the performance above 700 MHz, but nevertheless, we still think that this presents a big opportunity to increase the spectrum in this range.

So, therefore, we should set the requirement, so that we don't preclude using the same type of antenna as we use today from 700 to 960 and that will come at some penalty on antenna efficiency.

However, the good side of this is that this is, to some extent, compensated by the propagation characteristics as we go down. So in terms of coverage, that would, of course, improve. So that compensates some of the losses that we have from the antenna side.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: But that is the antenna performance that we would expect at least from a minimum performance standpoint.

MODERATOR PETERS: So the way you see

it, there is going to be a hit on the efficiency of the antenna regardless. Are there particular band plan frameworks that would -- could reduce that or are there others that might increase that, in your view?

MR. BERGLJUNG: We expect that we use the same antenna for receive and transmit.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: So of course, the transmit performance will also go down as you extend to lower frequency.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: The same applies also for the receive side, so whether or not you designate the frequency as downlink spectrum in a paired arrangement, downlink in a TDD part or SDL band that it will be affected in the same way, since we assume that we use the same antenna for transmit and receive, at least for the minimum performance requirement.

MODERATOR PETERS: Okay. Thank you. Prakash, please.

MR. MOORUT: Yes. So NSN has been working with Nokia and we filed a couple of, you know, simulation that we have done on UE antenna performance at 600 MHz. And really what, you know, I'm going to talk about really comes from our Nokia colleagues, who unfortunately cannot be here.

So one thing we notice in -- I think is known, is that these lower frequencies the portable radiates from the metal frame, so the size, you know, the device size in addition to the antenna size is also important.

So fitting everything into a 4 inch or 5 inch device, you know, is problematic at 600 MHz in general. And when you look at the different band plans that are shown there, you know, the two -- if you have like 2 x 25 MHz like in the proposal from AT&T, that was, you know, from an implementation point of view most efficient.

And then not far from that was, you know, like T-Mobile proposal of 2 x 35 MHz. The

FCC's proposal with the downlink below Channel 37, you now, obviously, had the least performance. And one other reason is because of the -- you know, the large bandwidth that is needed to support the FCC Band Plan that's more than 100 MHz in that case.

Again, I don't think, you know, we have come out and said that it is not doable. You know, I think all of these band plans are doable, but it comes back, you know, on the efficiency and the matching of the antenna.

MODERATOR PETERS: Great. I've lost track of who put up first, but let's go to Darryl.

MR. DeGRUY: Thanks. Darryl DeGruy from US Cellular Corporation. I really would like to hear more. I appreciate from Prakash hearing the antenna studies. We have talked to some device manufacturers and reviewed the record of the study that was put forward.

And our understanding, much as was stated by BlackBerry, is we -- it's going to be difficult to fit additional antennas in a device. So we are more than likely facing a device design that has one antenna.

As Nokia stated in their study, that antenna is probably going to have to be matched separately for each band that it has to cover, so that with those different matching elements placed together with the constraints of the duplexer, only being able to support roughly 25 MHz in the uplink and downlink, that causes a view that, as he said, the FCC has proposed or the green proposal of the paired probably is the most challenged from their study.

We have heard that from other manufacturers as well. I would love to hear more, additional comments from BlackBerry. We haven't heard from BlackBerry at this point yet.

And then the hybrid or the blue, keep the frequencies of trans -- simultaneous transmit and receive closer together, so naturally the bandwidth of that antenna for simultaneous usage and uplink and downlink are closer together in frequency, therefore, the bandwidth is narrower that the antenna has to support at one time. So that antenna can be matched to that situation easier is our understanding.

Again, I would love to hear from antenna manufacturers and device manufacturers, if I'm seeing the situation correctly.

MODERATOR PETERS: As you mentioned, unfortunately, we had an antenna manufacturer on the panel, but he fell ill this morning and had to cancel, unfortunately. But let's hear from David.

MR. STEER: So I think I echo the comments that we have heard, so maybe I'll try and amplify them and, of course, not speak against anybody, but I mean for us, as the device manufacturer getting an antenna in a device is the hardest thing to do.

We in our own case do design our own antennas. We have quite a few labs where we do that sort of work. We have many bands that we need to get in. And one of the messages is for us for working here, it's not just the 600 MHz antenna, it's the 28 other bands that we have to deal with as well.

People ask us why can't we put them all in? Because you need 28 antennas and they don't fit, at least not in a device that you can put in your pocket. And so that is literally our challenge is to try and find physically something that will do.

However, technology has got a lot of magic in it. And so I have seen design proposals for 800 and 700 put together that does enable us to get both of those in one package, in principle. Can we extend that down to the 600? Yes or no? Perhaps. I'm not sure. It's magic to do that.

I think it is true, and as I coin a comment that perhaps we just heard, that if we start having, for example, the primary proposal from the NPRM where the transmit and receive were separated by 90 MHz or whatever it was, that meant we needed 150 MHz bandwidth just in that particular antenna and that's not on, in a sense.

We could double tune it to get the transmit and receive and there are some advantages to doing that and we haven't actually done it, but, in principle, it could happen.

I think the principal comment that came to me from one of our designers last week was the antenna is kind of irrelevant in this band. It is the whole device that radiates. You put it in somebody's hand, you fiddle with the tuning and make the antenna plots look really nice when you measure them in the lab, put it in the device, put somebody's hand on it, it is just a piece of bent wire and it's not much better than that.

So there are issues with efficiency. The antennas at these bands and, you know, you know most of this, but 30 percent is a really good efficiency and that means three-fourths -- you know, two-thirds of the power is wasted before it gets to the antenna and has to leak out somehow, that's a huge loss in the battery, the same in the receive direction.

And so in terms of transmit and receive, it has the effect of shrinking it because we have knocked 3 or 6 dB off the, typically 6 dB, off the link budget. And so people are buying this spectrum to get large coverage because it's 600 MHz and it propagates well.

The antennas are so efficient, so we dropped 6 dB in the link budget, so they are shrinking back a little bit. So that is one thing to think about. So it is better from my perspective not to have things extending too far down. That means we have to go from 800 MHz to 400 and that's a 2-to-1, which is a huge number to do for antennas. If you do keep it above Channel 37, it makes it slightly easier.

So I talked about -- I mean, that is our major challenge. We have to think in the longer term of how to get antennas that will work not only at 600, but in the other bands as well.

The other issue or at least the other

side of the coin is there are things that are coming along, they are not available, so what are they? Technological Readiness Level 2 or something. I have seen some papers and some work that we have done externally, which enable the antennas to be tuned. And so there are some opportunities in the future for building these broadband antennas and having some internal tuning components, which enable them to be better matched at the various things.

So as long as you are only using one part of the band, you may be able to adjust components internally which enable it to be better matched in a dynamic sense. So at the moment, just to explain a little bit, we build the antenna for a particular band and it is tested and then it's shipped and it is fixed.

In the future, there probably is a possibility to enable components to be installed in order for the antenna to be tuned to optimize for the band, so it could be -- we could get better efficiency in the lower bands in the future.

Those things are not available off the shelf at the moment. They have limits on how far you can actually go and the power consumption is not terribly acceptable at the moment.

I'm an optimist. People will figure out how to do that if it is at the point where they can start to build on it and exercise it. So antennas are a big problem.

MODERATOR PETERS: Just on that point, do you have an estimate of about how many years out you are talking about that people will figure that out? I know it's difficult to say.

MR. STEER: I honestly don't know and I couldn't say, even if I did.

MODERATOR PETERS: Fair enough. Thank you.

MR. STEER: Thanks.

MODERATOR PETERS: Let's hear from Karri from T-Mobile, please.

MR. KUOPPAMAKI: Thank you very much. So my name is Karri Kuoppamaki. I'm from T-Mobile and I just want to echo what other people are saying here. Antenna certainly is an issue that needs to be looked at and at the same time, we want to keep in mind that the objective of maximizing the amount of spectrum while at the same time keeping acceptable kind of performance levels.

And hence, we agree with the comments that if you have your uplink and downlink far away from one another those performance trade-offs start to become quite significant and that would mean that the plans that we have in the middle, the down from 55 plans, potentially would be more feasible and have benefits over the plan on the top.

Also, to the point that they would have tunable antennas and, of course, the question would be with the middle plans is that what if you get more spectrum than 84 MHz, then what? And the supplemental downlink spectrum has the benefit that it potentially would be or most likely would be carrier aggregated with the high band rather than with the 600 MHz Band Plan and you could maybe tune the antenna and you would alleviate some of these issues.

So you wouldn't have to cover a very, very wide band if say 120 MHz of spectrum would be repurposed as an example.

MODERATOR PETERS: So one of the questions that comes to mind from those comments is, you know, we have postulated -- you know, we will talk about this in our later session, but is FDD in this band just too much of a challenge? And would a TDD Band, as shown on the bottom in the orange, be something that would help to mitigate some of the antenna challenges and improve efficiency and improve the utilization of the spectrum?

So I set you up, Rick. Go.

MR. ENGELMAN: Thank you, Tom. I think the answer is of course. But actually, I would like to call on one of our subject matter experts behind me. Craig Sparks works in our devices group at Sprint and he has actually looked at the issues of antennas and I think has some information to share on that.

MR. SPARKS: I'm Craig Sparks. I am in our Device Development Group and I'm an RF Engineer and I own in our group the conversations with our OEMs directly, including BlackBerry on device specifications.

So in this particular case, I wanted to make sure that the comments you made, Tom, when you opened about future technologies and in this particular case, tuning, and when that is available. And then to match that up against whether it is too early to expect that kind of performance for this, but it's not. Actually, it's mature now.

You wanted to know the date. It's our colleague here from QUALCOMM actually has mature part numbers that are -- that do that antenna tuning. It's a matter of antenna matching and aperture tuning on parts.

And actually, during our conversations with our OEMs right now, by the time we are -- we are requiring it right now in terms of being able to support multiple bands below 1 GHz in general, so we are talking, you know, whether we do 900 or 800, 700 and here comes 600. These antenna tuning technologies actually reduce the instantaneous bandwidth requirements.

So in this particular case, the points about needing more than 25 MHz and, you know, once we start getting above 4 or 5 percent, that's the trigger for these antennas.

And in this particular case, actually, TDD is uniquely positioned to reduce that instantaneous bandwidth and make the most use of that. And I just wanted to let you guys know that those conversations with our OEMs, that's an expectation for our devices coming up in the next couple of years and certainly by the time this band is viable that those technologies sit there and we will make use of them in our devices.

MODERATOR PETERS: Great. Thank you. We will hear from Sumit and then Steve.

MR. VERMA: Thank you. Just as -- I mean, I know it has been already kind of mentioned that it's a challenge, but, you know, just to kind of -- for me personally, I find this fact sort of illustrative that, you know, right around the lower 700 MHz range, the lambda over four hits around 4 inches and that's kind of illustrated to say we are going to be dealing with electrically short antennas in Smartphones. There is no way around that fact.

And so if you are dealing with an electrically short antenna, you know, physics dictates that you have a trade-off between bandwidth and efficiency. And this is not an opinion, this is physics.

MODERATOR PETERS: Yes.

MR. VERMA: And that doesn't change. And so from our perspective, you know, this is one of the reasons for us to have real difficulties, you know, with the down from 51 and 36 plan, because it really does create the most challenging antenna.

But our position simultaneously is not that FDD is not viable, it's just that, as was mentioned by US Cellular earlier, you just have to have a narrow enough FDD Plan, which is why we favor the 25 MHz-wide with a narrow duplex approach primarily for antenna reasons and the fact that, of course, there is duplexer reasons for that as well, 4 percent bandwidth and so forth.

And there was a mention of tuners as well, so what I would like to do is call on our technical expert, my colleague, Kent Walker, who has done a study on some of the trade-offs here.

MODERATOR PETERS: Kent?

MR. WALKER: Okay. Kent Walker. A number of issues here.

MODERATOR PETERS: Microphone.

MR. WALKER: Sorry. You have the situation where as you expand the FDD spectrum, it impacts the overall efficiency of the antenna. And in one study, we showed that just 10 MHz more bandwidth in FDD cost you a dB and a half in antenna gain. That's an example.

There are other issues closely related to the previous conversation with if you put uplink pretty much everywhere, then you have to guard band it and you end up guard banding to the bottom of 52. You also have to guard band to 37 on both sides.

And so SDL is better lower down and that's in addition to the issues that were already raised with respect to, okay, you have harmonics that are in band, B2, B41, B25, so that's about it.

MODERATOR HELZER: So if I could follow-up on those points a little bit?

MODERATOR PETERS: Sure.

MODERATOR HELZER: So I guess we have seen different numbers on what the bandwidth is, but it sounds like you -- I think, obviously, you are thinking it's more like 60 MHz because you -- or 70 because you prefer the 25 + 25 plan.

Would it be fair to -- are you, in fact, saying that by the time we get below 37 it is small enough that a second FDD Band doesn't make sense there? But it makes sense to do supplemental downlink or TDD down there because you don't have to have two carriers?

MR. WALKER: Yes. Going lower has multiple issues. You have the harmonics falling in other bands. You have the fact that 37 needs to be guard banded because if you run uplink adjacent, you are going to jam that.

So SDL in say 10 -- excuse me, 20 or 25 MHz chunks is a pretty nice choice. The antenna is not going to be a constraining factor and you are not going to have the issue of having to guard band Channel 37. So, yes, that works out pretty nicely.

MODERATOR PETERS: Thank you. Steve, you had your card up earlier.

MR. WILKUS: Yes, Steve Wilkus, Alcatel-Lucent. I first put up my card because I wanted to introduce the idea that TDD does have some advantage to -- with a tunable filter or tunable antenna as well as some intermod product issues as well.

But they all suffer from -- when you try to do carrier aggregation with very different bands and trying to -- you can't tune simultaneously at vastly different bands so far. But there are these existing tuned antenna schemes that are in product.

The -- I did want to just introduce another thing to you. The thinking here though is that it is not all handsets. There is more room in the tablets and fixed wireless loop for more sophisticated antenna schemes.

MODERATOR HELZER: So to kind of follow-up on that, this is just more of a pure technical question something that has been bothering us as we try to understand this. We hear a lot about how limited the bandwidth is and yet we know people try to do carrier aggregation of many different band combinations, some of which are harmonically related, which obviously leads to some interference problems, some of which are not.

And so one of the questions is just how is it that these very divergent bands can be supported on one antenna in many cases? And how does that relate to what the capabilities would be in this band?

So Christian is smiling, so if you want to take a shot at that?

MR. BERGLJUNG: Yes. Thanks. Thanks, Chris. As we mentioned in terms of antenna performance, of course, as you go down in frequency, there is a penalty to be paid and we quoted some numbers out of the previous experience. And those numbers we also looked at the possibilities of tuning in different ways.

And we think it is important to make sure that minimum requirements in the specifications do not preclude the use of single antenna, which is needed for interoperability and so on.

However, we see this as one of the biggest opportunities to realize part of the 500 MHz spectrum in the National Broadband Plan, so if it can be extended to 120 MHz, I think we should do our utmost to make that -- to realize that spectrum.

And in terms of antenna performance, there is a penalty to be paid. And the problems of intermodulation and harmonics, yes of course, that is going to increase as we increase the number of frequency bands that we need to support the services. That is inevitable.

So, as long as we make sure that the antenna problems are not insurmountable, we should do our utmost to make sure that we can actually clear 100 MHz of spectrum for this.

Finally, I would just like to make a comment also on the SDL use in the lower part of the band and we would like to recognize that we will most likely use the same antenna for the TX part and the RX part. And diversity performance will go down as you go down in frequency and that's also inevitable.

Of course, to some extent that is compensated by the coverage properties at those lower frequencies, so I would also assume that an SDL use would firstly have the same penalty in terms of antenna to receive performance.

MODERATOR PETERS: Yes.

MR. BERGLJUNG: And it would also assume that you combine that with a high band and, of course, that raises some questions on fungibility of spectrum. And I assume that we will come back to that later. But just to reiterate, we have got a big chance here to allocate a large amount of spectrum and we will try to do that unless things are insurmountable.

MODERATOR PETERS: Yes, I totally agree with you. And I have to, you know, say this goes to the trade-offs that we were talking about in terms of, you know, the amount of spectrum that we can support versus the performance hit that you are going to take and where you draw that line.

You know, quite frankly, going into this, at least, you know, my personal opinion was that, I expected the wireless industry to want to, you know, repurpose as much spectrum as possible. But one way to interpret some of these antenna arguments is that, you know, maybe less is better. And so, you know, we are interested in understanding where those trade-offs land.

In that light, maybe, Sanyogita, you can shed some light for us?

MS. SHAMSUNDER: Less is not better.

MODERATOR PETERS: Great. Thank you.

MS. SHAMSUNDER: Okay. By the sense of most of the comments here that 25 x 25 in the 10 MHz duplex gap, 10, 11, whatever, we can argue a little bit here and there, would be the most optimum in terms of manageable device complexity performance and size to the critical parameters for going forward for our Smartphones.

But if you are in a position where we do clear 120 MHz almost everywhere, you know, if you remember almost everywhere is maybe, I don't know, whatever number you choose, then I think we can push a little bit in terms of what -- how much paired spectrum we can get.

So no doubt it will be -- it will come with some price, but it's a compromise that I think we, you know, as industry, have to figure out if it's worth it because there is an impact to the size. You know, you will have a larger antenna. You need a tunable antenna. And you will definitely see some loss of performance, a couple of dBs, so there is -- it comes with a price.

But if you are going to get 35 and 35 in most of the country, I think we have to live with that. Thanks.

MODERATOR PETERS: All right. Thank you. Let's hear from Harold, please.

MR. FELD: One of the things that comes out in this discussion, which highlights the complexity of band plan structuring here is -- and I don't know the answer to this, but I do suggest is that there may be break even points with regard to -- that would have significant implications for total bandwidth orientation, not just simply we try to add new downlinks for each, you know, reclaimed spectrum.

But the difference between some of these, you know, trade-offs is, you know, if you imagine you had 120 MHz to play with versus if you imagined you have 60 MHz to play with is extremely -- you know, is radically different. And I recognize the challenge in that, but it does seem that, you know, to the extent possible and I'm not -- again, this thing goes to the how do you -- you know, kind of the economics of the auction, the auction structure.

You know, are there break even points on reclaimed spectrum where you could flip a -- you know, would want to revert to a different band plan or given the simultaneity of the two pieces of the auction, does that just create too much complexity because bids on the, you know, forward part become -- are dependent on assumptions about the nature of the band plan being fixed.

MODERATOR PETERS: Thank you. Good comment. Darryl?

MR. DeGRUY: Sure. I wanted to

speak to that question. It is hard for us to come up with a dedicated band plan without knowing that very answer. What is the lowest common denominator of how much spectrum is going to be cleared? And that's a challenge, right? I think we all see that the same. Without knowing a magic number or magic numbers if it were two different sets of the lowest minimum clearing.

If there could be a mechanism in the auction to threshold limits in markets to where, you know, a market is cleared to a certain level is the first goal and objective, might provide some clarity in that it is all I suggest.

I did want to clarify an earlier statement. I'm not suggesting that US Cellular wants less spectrum by any stretch of the imagination. The more FDD cleared spectrum available, the better. The more we can compare that within the 600 MHz Band the better for us as well.

So I just wanted to clarify that we are not seeking less.

MODERATOR PETERS: Okay. Thank you. We've got a few minutes left so let's hear from Sumit and Karri and then Rick and then David. And then we will break for lunch.

MR. VERMA: I just wanted to kind of emphasize again that more than likely what would happen is we would be using the existing 700 MHz antenna in most UEs or Smartphones. And so we are talking about, you know, some sort of degraded performance and the question is to what degree is it manageable. I think that's the point that has to be clear.

No band plan is going to be perfect, but some are going to be better than others. And this is why I think for us we do favor the 25 MHz FDD and supplemental downlink below that primarily for this reason, because we are, in a way, already assuming some sort of tuner would be part of the equation, because you would have to take that 700 MHz antenna, tune it down and it would still have a trade-off.

I think Kent was alluding to this

earlier. There will be a trade-off of efficiency and bandwidth. The wider the bandwidth the band plan has, you will take an efficiency hit, that's the trade-off.

And the nice part of SDL is you only have to tune to the SDL itself. It is no longer paired and so that's why as you go lower in the band where the penalty becomes more severe in terms of the trade-off, you can limit yourself to the SDL. Whereas in the upper part of the band, we believe that while there is a little bit of a trade-off, you can manage a 2 x 25 band plan with a narrow enough duplex gap. Thank you.

MODERATOR PETERS: Thank you. Karri?

MR. KUOPPAMAKI: Oh, thanks. Yes, I just wanted to follow-up on some of the previous comments with regards to how much spectrum, you know, what makes sense below 51 and above 37. And we have spent a fair amount of time looking into this and agree there is no such thing as free lunch, but at the same time considering having

40 percent more spectrum than in the case of 25 + 25.

In other words, if you go for 35 + 35, we certainly think that it will, you know, weigh much more than, you know, maybe some of the compromises that would have to be made if only 25 + 25 is allocated.

And then the other thing related to the supplemental downlink, so if you have supplemental downlink, both above and below Channel 37, then that is not trivial either and may fragment the band plan a little bit more. And hence, having a paired spectrum about Channel 37 and maximizing the amount of spectrum above Channel 37 makes perfect sense.

MODERATOR PETERS: Thank you. Rick?

MR. ENGELMAN: I'll make a comment. Thank you, Tom. I think this discussion is very good. I think it also points to a lot of the issues as to why Sprint has been pushing for the TDD approach. I mean, there probably is no band plan that is more simple and easy to accommodate whatever comes out of the auction process. You don't have to worry about guard bands for multiple situations. You really have a single band to deal with from an antenna perspective.

You don't have to worry about the complications from that. I think you don't have to constrain the amount of spectrum that is available for competitive entry into this market. We are very concerned about a 25 + 25 plan that inherently is going to limit how many people have access to the band.

You can't use the supplemental downlink unless you have some way to get a signal back from the device. And so it really isn't useful unless you already have spectrum for a variety of reasons and this is one of the areas, I think, you know, we favored TDD.

I'll admit it doesn't come -- there is no perfect answer here. There are issues, but I think this does, in this particular area, address a lot of the concerns and issues. Thank you.

MODERATOR PETERS: Okay. Thanks. We've got about five minutes, so I think we have time to hear from David and then Prakash.

MR. STEER: I'm glad. I was afraid I was going to be the last guy before lunch and I hate speaking that way and I certainly won't talk for five minutes.

You had asked earlier about the level of importance of things. And I think that the antennas issue is probably one that is not at the top. It's very important, but I think, as we have heard from the discussion, making sure that the appropriate amount of spectrum is allocated or made available, we will figure out how to make the antennas eventually to work, tunable antennas and various things.

The second one was I forget whether I -- when I was remarking earlier about the bandwidths and so the current technology, as we have seen it in our labs, is about 10 percent bandwidth. And so that is measured in the antenna lab.

The guys tell me when they put it in the handset and somebody grabs it, it's about 7 percent and even that is sort of out to like 30 percent efficiency kind of level where it is down 6 dB or something, 5 or 6 dB from the peak. And so not a very good antenna, but that's the kind of bandwidth.

And so those are -- that's kind of where we are at the moment. And one would do better than that with the tuning, which would enable things to happen.

I'm -- you had made the observation about up and down and so on at the moment and, of course, we already do have in the devices antennas which are double tuned. And so we end up with two feeds on them and they resonate at 800 and twice that or somewhere, so we get the two bands and we are able to work the -- we are able to do the associations through the uplink and downlink.

MODERATOR HELZER: Thank you for

coming back for my question from 10 minutes ago.

MR. STEER: Yes. So and I'm amazed that I remembered it. And then, finally, I wanted to comment though on that we need to -- there are still issues with filters with the bands. And so you might sort of -- we have heard the question about the TDD and myself am in favor of TDD in many respects, but it still leaves us with the filtering issue.

That if there are TV channels in the -- we can make an antenna and we don't have to deal with uplinks and downlinks and so on for one particular TDD channel, but if in some areas that is going to be a TV megawatt station and in some areas it is going to be a mobile up and downlink station, I have still got to build a filter that is going to deal with that, so that it -- to make it work.

And so the FDD Band Plan is in many ways easier for us, even if we have to do a transmit and receive. And in some proposals we have double tuned antennas for the transmit and receive direction and, in fact, that is an advantage at times. Thank you.

MODERATOR PETERS: And that comment reminded me of another question, which is, you know, in an FDD Band assuming, let's say for example, it's 35 + 35 MHz, yet, you know, it would be unlikely that one carrier, one operator would have all 35 + 35 MHz. So is there a possibility that the antenna would only need to tune to part of the spectrum at the time and not necessarily to support the entire 35 + 35 simultaneously, but only maybe 20 + 20, for example? And then when tuned to an operator that has spectrum at the other end of the band, it tunes to the other 20 + 20. Is that a possibility with tunable antennas?

Prakash, I'm not sure you can answer that, but --

MR. MOORUT: In answer to that question, the point I wanted to make was I do agree with Sprint on the flexibility of TDD, you know, allows that band for various reasons and from an antenna implementation point of view also.

There are other issue with TDD and maybe we will get into those, you know, later today, but, you know, we can discuss.

And then the other comment I wanted to make was with respect to, I think, what T-Mobile and Verizon were saying, you know, we also want to maximize the amount of spectrum. When you look at the comparison of the 2 x 35 MHz, you know, proposal from these two operators versus 2 x 25 from AT&T, for example, you know, the hit to the efficiency was about, I think, 0.5 to 1 dB from antenna point of view.

So and just looking at just the, you know, 600 MHz antenna and not 700, you know, tuned down to 600. So I think 2 x 35 is a good compromise between maximizing the amount of spectrum and antenna efficiency point of view. And obviously, the TDD solution also is, you know, a good way forward. So we can discuss that, I guess, later.

MODERATOR PETERS: Thank you. I'm

not going to let Christian get off the hook. You had your card up. Do you have an answer to the question?

MR. BERGLJUNG: Yes, thanks. On the proposal to do different tuning for different parts of a band. We think that that would not be very well for interoperability, since we would like to have -- be able to make devices that could work for any operator.

So if that's a fixed tuning to a certain band, we will not do that. Thanks.

MODERATOR PETERS: No, I was thinking of variable tuning that, you know, the same device could operate on different parts of the spectrum with the tuning varying.

MR. BERGLJUNG: Yes, it's a different band.

MODERATOR PETERS: Yes, okay. A couple more minutes. We have a good discussion going, so I hate to interrupt it, but, Sumit, did you want to weigh in?

MR. VERMA: I think one of the key

issues is now you are essentially mandating an active tuner. Whereas, before, while I sort of alluded that that could help, it didn't necessarily have to be absolutely required. You could have worked without it. So I think that's probably the main point.

And I know we haven't talked about duplexers much, but I think it should already be clear that if we were talking about a wider than 25 MHz band plan, we are talking about not being able to support that in a single duplexer. So you are already talking about two different bands there, not just one FDD Band with two different duplexers.

MODERATOR PETERS: Yes, that's the subject of the next panel.

MR. VERMA: Oh, sorry.

MODERATOR PETERS: No, that's okay.

MR. VERMA: And we had mentioned fungibility earlier and again that comes into play, but strictly sticking to antennas, yes, this -- while it is not clear whether it would work or not, it would certainly now be mandating an active tuner and that only works in the very specific sort of option where there is sort of immediately overlap.

If you were to have uplink lower in the band, that is where we, I think, have more serious technical issues.

MODERATOR PETERS: Okay. Thank you. Darryl?

MR. DeGRUY: Yes, I just wanted to carry on to what was talked about with interoperability. Obviously, US Cellular has concerns with interoperability. And we want to make sure that interoperability is taking place when auction -- when carriers support 600 MHz Band.

So some challenges with some of the comments made here. Supplemental downlink can't stand on its own. It has to be paired with another band. So, therefore, each licensee is going to have a different set of licenses in the underlying or overlying market that they would want to pair it with.

And facing what we face with Band 12 versus Band 17, interoperability is an example, high volume carriers or high volume device sales kind of pushes the economics for the device manufacturers and component manufacturers it seems.

So we fear a lot of attention being placed if a supplemental downlink scenario is placed. Who decides what that gets paired with? I guess that's an interoperability concern as an outcome of that scenario.

And then a second point is with the TDD. One of the challenges that we have heard is the ability to synchronize multiple operators in the same space. So while there are TDD deployments around the world, it seems to be, you know, that there is a control -- one controlling entity that synchronizes adjacent blocks to each other, so that when devices are transmitting up, other devices are, you know, in synchronous operations with that.

We see -- we would like to hear the -- how that challenge would be addressed in the TDD scenario where different licensees would have TDD operations and how that synchronization could take place. Thank you.

MODERATOR PETERS: Okay. Great. Rick, maybe you can address that quickly? We are a couple minutes over and then we will go to lunch.

MR. ENGELMAN: All right.

MODERATOR HELZER: And if you can't do it quickly, we do have a whole panel on technical flexibility after lunch.

MR. ENGELMAN: Yes.

MODERATOR PETERS: Right, right.

MR. ENGELMAN: Yes, I'm happy to-- I actually wanted to respond to the question Tom had previously. So if you want me to post -- I can respond to this as well, if you want, but --

MODERATOR PETERS: We have all afternoon. We are good.

MR. ENGELMAN: We will push that part to this afternoon, Darryl. But our thoughts and our discussions in looking at the filtering and the antennas issues that is, in fact, one of the ways you can best use this spectrum, it particularly works well for TDD, is you can tune the antenna and use the parameters of the antenna to provide some of the filtering that is needed for adjacent issues along with tuning filter banks that can kick in and make sure that, in fact, the device has the necessary protection from adjacent channel interference issues.

And I think that is something that is possible, so I think the antenna tuning works in parallel with the filtering in the filtering banks to provide interference protection.

MODERATOR PETERS: Okay. Thank you very much.

MR. ENGELMAN: And on bandwidth--

MODERATOR PETERS: Okay.

MR. ENGELMAN: I'm sorry. LTE and most people are talking about LTE, the bandwidth is up to 20 MHz is the width of the channel. So from that perspective, you can look at tuning in a way that is centered on LTE, but it has to be interoperable. You want to have the devices so they do, in fact, work throughout the band plan.

MODERATOR PETERS: Yes.

MR. ENGELMAN: Thank you. Sorry.

MODERATOR PETERS: Well, thank you. That I think concludes the section on antennas. And, Cecilia, you want to make --

MS. SULHOFF: Yes. Just to remind people, there is a handout over there, we do have a cafeteria here in the building, but we do have a handout with some eateries that are close by. We will have a couple of people in the back, if you don't know how to get down to our cafeteria, that will walk you down.

And then at about 1:10, 1:05, we will have somebody back down there to bring you up if you need help getting back.

I know we did run five minutes over, but we would like everybody to try to be back around ten after or so, so we could start at 1:15, if possible. Thank you.

MODERATOR PETERS: Thank you.

(Whereupon, the meeting was recessed at 12:21 p.m., and reconvened at 1:19 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

1:19 p.m.

MS. SULHOFF: So as a quick reminder for anybody who might have joined us late, if you are watching remotely, you may submit questions for the Moderators by sending an email to livequestions@fcc.gov. Please include your name and your company affiliation with your question.

And again, those sitting here if you arrived late, we do have some notecards and pencils on the back table. Please write your questions down and give them to one of the FCC staff members in the room.

If you think of a question, please, submit it as soon as possible. There isn't going to be a designated question and answer period. Thank you.

MODERATOR PETERS: So welcome back from lunch. I hope everybody enjoyed the wonderful cafeteria food. Welcome to our third topic, which is going to be filter pass band issues. And co-Moderating with me on this particular topic will be Michael Ha, to my right.

So the issue here is specifically the pass band of the filter and how that might affect various band plan options that we have talked about already today.

One example, realistic example we can turn to is the Asia Pacific 700 MHz Band Plan, which is a 45 + 45 MHz Band that is actually a single band class in 3GPP, Band 28, but it is implemented with two duplexers that overlap, so there are two 30 MHz duplexers that would overlap in the standard or would overlap -- that's actually not in the standard, by 15 MHz.

And so in doing that, they are able to achieve worldwide scale as well as interoperability, which, you know, as Ruth mentioned this morning one of the goals of the band plan exercise before us.

So we wanted to have a 45 minute session where we talk a bit about how this -- how these band or filter limitations affect the band plan. And I guess the obvious place to start is at this frequency range, 600 MHz.

How much pass band can we support in a single filter? What are the limitations there? And what effects do they have? Anybody want to start us off?

MR. MUELLER: I do.

MODERATOR PETERS: Oh, William, yes. Of course, William.

MR. MUELLER: I am William Mueller with Avago and again we are a filter manufacturer.

Being an engineer, I'll go farther than I need to on this, but I want to be clear about some of the capabilities.

First of all, if we are talking about in handset filtering, for size reasons, we really are talking about using acoustic filters rather than electric filters. And that's what creates the bandwidth limitation.

If we were free to go to electrical filters like ceramics, which would be a size penalty, it would be, I don't know, half the size of the phone maybe at this frequency, but you could physically do it and do whatever band plan you wanted and whatever roll-offs you wanted. So to your comments early this morning, it's a trade-off.

MODERATOR PETERS: Right.

MR. MUELLER: If we go into acoustics, we don't have the flexibility of arbitrary band plan. What we have is a series resonator and a parallel resonator that we are pulling some distance apart. And at a certain point, you pull them far enough apart, the middle sags down and you don't get a good band pass. So that's what it comes down to.

And that means it relates back to materials properties. If you look at the materials properties and the filters that are used today, what we can support is a bandwidth that is on the order of 4 percent intrinsic. And we can stretch that a little bit, maybe 5 percent or so, if we play games with the circuit design and what the consequence usually is is somebody far away from the pass band attributes degrade.

So you may get poor rejection of very high frequencies or even get what we sometimes characterize as wings where we get regions in closer that are a little bit higher and a little bit lower in rejection.

So if you look at today's technology, I think it is pretty clear that we can do 4 percent easily. If you look at the materials that are available and the work in materials that is going on in the labs, I would be willing to stretch that a little bit. So you can maybe get up to 6 percent, based on what you are seeing from that.

If you put that into megahertz down here and it is percentage, what that says is 20 MHz is easy, 30 MHz is probably possible in the not too distant future and 40 MHz you are not going to make a good duplexer.

MODERATOR PETERS: Yes.

MR. MUELLER: There is a little more to it than that. Sorry. As you stretch the bandwidth, you use up the capability design you have and you lose steepness. So if you want both a narrow gap and a wide band, then you have to pare down on the bandwidths. So that 30 probably doesn't go for the narrowest duplex gap you could get.

MODERATOR PETERS: Just a question for clarification. When you mentioned today's technology, are you referencing specifically SAW surface acoustic wave or BAW or what?

MR. MUELLER: Okay. So if you look at materials, the most common surface wave devices down here are lithium tantalate and the most common bulk wave are aluminum nitrate. Both of those have acoustic couplings. They are in the 7 to 8 percent and you can get to half that bandwidth in terms of native bandwidth of filters without stretching the design.

There is also a surface wave technology called lithium niobate. It has a wider bandwidth capability. It has downsides to that in terms of the consistency and bigger temperature motion, so there is trade-offs in all of that.

So I think any of the acoustics, that I'm aware of, fall into this kind of range. And then there is work being done. It is mostly at university and private level right now in terms of, I'll call it, materials doping where you get a more elaborate lattice that you are working with and that is what increases the acoustic bandwidth.

That is not in manufacturing. It has been demonstrated in the lab, so the physics works, but the manufacturing capability on it isn't there yet. And that's what I'm talking about when I move from 20 MHz to 30 MHz.

MODERATOR PETERS: Great. Thanks. Sumit?

MR. VERMA: Thank you. So we took a pretty careful poll of all the surface acoustic wave vendors and, William, I'm assuming Avago is not going to be doing a product that is 600 MHz? Maybe I'm wrong. We did ask you as well, but we got a very clear response that -- about -- given the existing technology that is low cost that would be highly desirable to use, that beyond the 4 percent that William correctly pointed out, things would start to fall apart pretty badly, so that is where we got the 25 MHz number from.

At 30 MHz, the isolations of the duplexer were unacceptable. While it could technically be built, it wasn't built with the fidelity that would be required for a high quality duplexer. And so beyond -- it's certainly not at 35. So at 35, we would be looking at two duplexers, I think, as was mentioned before.

And while the other technologies that William mentioned are interesting, it's not obvious to me that they would be the ones used in a -- would have the cost and the other targets that would be necessary or even really be available at the time that we would wish to implement this. So thank you.

MODERATOR PETERS: Steve?

MR. WILKUS: Yes. We are doing some of the same things and have had some of the same discussions. And having worked on surface acoustic wave devices about 25 years ago, I'm very impressed at how far the industry has come and the capabilities of filter manufacturers.

But what I think is some important little points to make is that below Channel 37 it looks like, you know, at the lower frequency, the lower side of 600 MHz, you know, maybe 20 MHz is about right. And at the high end 25 MHz may be about right. Maybe as much as 30.

I'll also point out that when we were looking at the third harmonic issues, that more than 30 MHz of uplink spectrum starts to overlap the -- one-third of the PCS Band. And so 30 MHz or six carriers of down-- of uplink at the high end of the 600 MHz Band looks like you don't want more than six, five or six. You know five can work. Six is based on how much we want to twist William's arm here and think more about the future materials that are more temperature-stabilized perhaps and doped.

But I think we also have to keep in mind that the supplemental downlink below 37 may be more restricted because of the lower frequency by that same 4 or 5 percent fractional bandwidth.

MODERATOR HA: So in terms of a trade-off as Tom kind of highlighted earlier in the morning, you know, suppose we clear sufficient amount of spectrum and, you know, we want to look at something maybe a little bit bigger than 25 MHz and we talked about supporting a dual duplexer or having two filters supporting large bandwidth.

Can somebody comment about trade-offs of doing that versus -- you know, it's similar to the antenna discussion earlier that, yes, there is some, you know, physical properties that really optimizes your performers in terms of the losses, onto the matchings. And I think similar trade-offs exist on the filter design as well.

I think it will be very beneficial

for the audience here to understand what trade-offs that we are looking at. If we were to enlarge the bandwidth by deploying two duplexers which has been done, I believe, early PCS handsets had some sort of a split duplexer, because of similar challenges.

And I think it was very helpful for the audience to understand. William, I think you have your card.

MR. MUELLER: Yes. I can comment on that a little bit. If you do a split duplexer, a couple of things happen. One is the duplexers actually get quite a bit easier because the duplex gap widens a lot. It widens by the amount of the overlap, so you don't have to worry about steep edges on the inside of the duplexer as much. So that's a benefit of it.

The downside is it functionally operates as a separate band. It has got a different hardware path. And so, in a sense, you are naming it as one band in the standards, but until a new technology comes along, in hardware it's really two bands and that's the major downside.

So if you look at modern phones, it's not really the filtering that limits how many bands you can put in the phones, it's the switches. You only have a certain number of throws you can put in parallel before the performance of the switch becomes unacceptable for modern phones.

And so now you are using two throws rather than one. It is one less other band that you can include in the phone. So that's really the main thing. It is a control -- you know, if it were a single band phone, I would say you are getting the complexity up a lot and that's why it didn't survive in PCS, but back in those days, you didn't see 15 band phones and now they are relatively common.

So the penalty today is more relative to putting in -- this band costs you two bands worth, if you will, rather than one band worth. But that's going to end up happening if you stretch a wide enough percentage bandwidth just because of what we are able to do in the technology down here.

MR. BERGLJUNG: Is --

MODERATOR PETERS: Christian, I'll get -- we'll get to you in a second, but I just want to ask along the lines of what you are saying, William, regarding the trade-off, let's say the limit is 25 + 25, just for argument sake.

And that if we were to repurpose a band that would support 30 + 30, in your mind, would that be something worth doing, adding a second duplex or just to get the extra 5 + 5 or is that -- and that's just an example. And I'm wondering maybe more generally is there some sub-set based on the filter band with limitations? Some sub-set of band plan paired spectrum that we shouldn't consider based on those limitations?

MR. MUELLER: Yes, good question. So to refer back to the Asia Pacific Plan, the Band 28 Plan you mentioned earlier, what the assumption was there, as I understand it, is that in most regions that spectrum would be held by three carriers each with a 15 MHz piece of spectrum.

And so the plan allowed you to have up to 15 and be able to fit through the duplexers. You didn't have to worry about somebody in the middle getting their band split and then this hardware wouldn't support it.

So what that says is the overlap has to match with the amount of spectrum you can support. So if you are looking at this kind of spectrum down here, you are probably going to need a 5 or a 10 MHz overlap. And then if you look at the bands we are talking about, if you take the 20 or 25 MHz number, if you use the wider overlap, you start adding up lots and lots of duplexers in a hurry and that probably becomes impractical.

So there is a significant cost for a small amount of spectrum in that. If you wanted to free the whole 100 MHz, it would take either three or four duplexers, depending on how many -- you know, how much overlap you wanted to have.

It may be worth making one other point. We did talk about TD earlier. In duplex design, you need deep rejection, because you are worried about desense. You need about 50 to 60 dB rejection in modern designs.

MODERATOR PETERS: Yes.

MR. MUELLER: In TD, you are more worried about external blockers and the emissions. You typically only need 40 dB or so. So that actually cuts down on guard bands and makes wider filters easier.

And we have filters in the market that are 7.5 percent for TD. So in TD, we can actually do wider bandwidths and filters. We have got existence proofs in that.

There -- to QUALCOMM's point earlier, there is a cost in that. Those filters are complex and they are not cheap. So you have that trade-off to do, but that's normal in technology. If you push the limits of it as you implement initially, it costs you more, as it gets commoditized, it comes down in price.

MODERATOR PETERS: So just to do the math explicitly, 7.5 percent for TDD means you would be able to support 45 MHz of spectrum for TDD, at this point?

MR. MUELLER: So I'll say 40.

MODERATOR PETERS: 40?

MR. MUELLER: But my numbers would be like 20 is really solid for present filtering and as Sumit was saying, the existing technology base 20 to 25 is a really nice place to be and that's what the technology out there does.

If you go towards 30, it is probable by the time this is deployed that you can find technologies that do that. It won't be the cheapest thing. It won't be the most mainstream thing.

And if you go beyond that, you are probably talking, really stressing what we know how to do, taking a risk of not being able to do FD.

MODERATOR PETERS: Yes.

MR. MUELLER: For TD you can probably go up to around 40.

MODERATOR PETERS: Okay. We will go to Christian, but I before we do that, I just want to read a question from the audience, which is something we can all think about as Christian is giving his response.

The question is what happens to the size of the handset if two duplexers, let's expand no and say two, three, four, if multiple duplexers are required to support the band?

MR. MUELLER: If you don't mind, I can answer that real quickly.

MODERATOR PETERS: Go for it.

MR. MUELLER: Which is the present size of a duplexer is about 1 millimeter by 2 millimeters. So the answer is not much. You wouldn't notice it externally. It's really the question of which other band you took out and put it in. It has already got -- most modern phones have six or seven duplexers in them already.

MODERATOR PETERS: Okay. Thank you. Christian?

MR. BERGLJUNG: Thanks. Some comments along the lines that William already made, but maybe I should comment on the duplexer size first. In many of the phones today, even adding extra duplexer, even if it's only 1 millimeter by 2 millimeters or even smaller, an additional component is still a cost, even if it's that small, because there are often a lot of other components that need to be fed into the phone that should be -- have a nice form factor, etcetera, so that's definitely a concern.

But coming back a little bit to this on the split duplexer issue in the band and the APT Band that is specified as a 2 x 45 MHz Band and there is nothing in the specification that talks explicitly about this split duplexer arrangement. But we have still made some assumptions that still means that you can or you basically have to inter -- implement it with this split duplexer because that's the only way to do it.

For example, you can only support up to 50 MHz bandwidth without constraints and intraband carrier aggregation beyond 15 MHz. It is not possible in that type of arrangement.

So along similar notes at least in the Ericsson comments on the band plans that we are providing, we have just assumed the legacy 4 percent, the same filter bandwidth and that could also be used for setting the minimum requirements.

However, for example, in our TDD plan that we have proposed also with filters, of course, there is opportunities there to, in a real design, use fewer filters with wider bandwidth, if you can still meet this minimum requirement. But we still think it is essential that we use perhaps today's legacy capability at least for the minimum requirement to make the bands feasible in a short time, so that we can implement this band in a short time.

MODERATOR HA: Okay. Why don't we

go to Karri and then Sumit?

MR. KUOPPAMAKI: Thank you, Michael. So -- and thank you, William, for the introduction. I think it is important to keep in mind that, you know, technology evolves and that's constant and that's why whatever is in place today, you know, tomorrow it will be better and that's something that we should certainly acknowledge as part of this.

To address your specific question on what are some of the trade-offs associated with, if worst comes to worst and we have to implement you know two duplexers, we have also looked into this and we think that trade-off is certainly something that is very acceptable.

So -- besides we already talked about you know, yes, there may be a small penalty, but again, I think the benefits of having a larger bandwidth available certainly outweigh some of those trade-offs.

And in terms of performance, we are not looking at multiple dBs we are looking at maybe some tenths of a dB rather than, you know, 2 or 3 dB, which it would be a significant penalty.

So all in all, I think the filter even if you have to go for a filter approach, it's something that would be acceptable and certainly justify having a wider plan in place.

MODERATOR HA: Thanks. Karri, Sumit?

MR. VERMA: Thank you. Just a couple of points. I think what -- one of the things William had mentioned was the wider bandwidths up at near sort of the Band 41 range up at 2.5 GHz.

Our understanding, and this is again based on the feedback we got from a query that we had sent out to all the filter manufacturers, is that, yes, you can get that kind of percent bandwidth for TDD filters in that frequency range up in the 2.5 GHz range, but as you get down to 600 MHz, one, the percent bandwidth supported do shrink.

And then the second item to note is

the kind of performance that we are going to be looking for in terms of isolations and attenuations of megawatt TV, you can't just have a low Q filter either. You would have to have a very high Q.

So those kind of things have to factor into the percent bandwidth. So while the 4 percent number is representative today, it wasn't really obvious to us from a broad swath of the market that a lot of the vendors -- maybe Avago has a slightly different view than the others, but were really willing to sign up for a much significantly wider than that.

And then the other thing I just want to point out is if there is a two duplexer implementation, there would be a switch after it. And then we would really have to be extra careful of carrier aggregation implementation -- implications, because a switch is after all capable of generating non-linear harmonics and so forth. Thank you.

MODERATOR HA: So we will get to

that, the other switches and the carrier aggregation in a second. But let's go to Darryl and then Prakash.

MR. DeGRUY: Thank you. So I guess a view I would like to point out is dual filters or two duplexers are required, that needs to be taken into consideration of maximizing the spectrum also, as well as providing as much attenuation TV stations that are left.

So the lowest common denominator that we talked about earlier about how many TV stations would be cleared, I think if we end up going down a dual duplexer solution, which probably sounds like the most practical solution, at this point from what I'm hearing, the placement of those discrete bands, I guess, whether you want to call them one band or two bands, that those duplexers support, should be able to reject TV that is left in the band by switching to one duplexer.

And also maximizing -- while at the same time trying to maximize how much spectrum we can have available for auction. So that's the view I would like to point out or put out there is that we need to work together hopefully to accomplish all those goals within how this band is laid out. Thank you.

MODERATOR HA: Thanks. Prakash?

MR. MOORUT: Yes. So, you know, Nokia has asked for details from several duplexer vendors. I just want to provide some additional inputs here. And, you know, as Bill, as William, said, you know, the importance of size is negligible, that's what we were told. In terms of the cost impact, an additional duplexer would be adding cost of a few tens of cents.

There is obviously a switch that is needed after, that introduces a loss of about 0.5 dB, not 2, 3, 4 dB. And then the complexity would be like adding a new frequency band. So it's not something that is not doable.

And we also discussed that before. In terms of the overlap between the two duplexers, you know, it depends on the maximum channel bandwidth you want to use for that particular band, so, because you can use only one sub-band at a time. So if you wanted 20 MHz, for example, channel, you could present you may have channel, you know, if you have, for example, two duplexers that are each 27.5 MHz wide.

Then the overlap would be 20 MHz and that would cover 35 MHz. So you know 2 x 35 MHz option that was put on the table for us looks feasible, so and it also allows maximizing the amount of spectrum compared to some of the other options now.

MODERATOR HA: Okay. Thank you. Darryl?

MR. DeGRUY: Yes. Sorry, I did mention one thing I wanted to ask earlier. William pointed out the number of switch throws that were available today. I would like to hear -- I don't think we have a switch vendor here, but what are the current limitations in devices that are manufactured today? Are there some constraints?

And I know in the past, certain chipsets only had a certain number of ports that could support certain bands. So where do we see that going from a device-perspective?

MODERATOR HA: Yes, thanks, Darryl. That was my next question. And last year we had a working group from our TAC, the Technical Advisory Council, on the multi-band radio, so we spent some time, but I would like to ask our panelists here to talk about how many bands do you see on your phones today and how do you think it is going to be going in the next few years? You know, from both handset perspective as well as chipsets capability perspective. And I see that there is some differences between the two. So, William?

MR. MUELLER: To address Darryl's question, and I'll let yours go on to the OEMs, because we do both filters, power amplifiers and are looking at integrated areas in the front end, we also do switches. And where the technology is today, 12 to 14 throws is kind of what is common in the high band count.

I have seen one 16 throw switch out there. If you were asking me a couple of years ago, I would have said 10 to 12, so it's sort of creeping up the curve. It is kind of a leakage and isolation in the physics of the switch that is limiting that. And it doesn't look like we are going to get a big breakthrough in that any time soon, unless somebody comes up with a different switch technology, but there is some work there that is promising that is an area that improvement could happen in.

But there is one other piece to this which is we have mentioned carrier aggregation a number of times. The most common architecture for that causes the switch to be split. One switch covering low bands, one switch covering higher bands and a diplexer combining them.

It adds a little more loss, but now you have doubled the number of bands you can put in, you know, assuming an equal number of low and high bands, because you have a lot more throws available.

So the limit right now seems to be mid-teens going up towards 20 with today's technology.

And the other part of this is there is a difference in the output switch and the switch coming out of the amplifier. The amplifier is aggregating, so it needs to be distributed into the filtering. That switch usually is not that big of an issue in how things are done. It is usually built into the power amplifier and the way that is designed. And the power amplifier is sized to overcome any losses of that.

One other thing to be clear on is because we are talking about high throw count switches already having this extra throw on there, isn't an added loss relative to the duplexers, but it is correctly pointed out that from an aggregation point of view, you get one side or the other side and you would have to move the aggregated piece in front of the switch if it is another low band.

So there is some complexity in that.

MR. WILKUS: When you say throws, is that the same as bands or half the bands?

MR. MUELLER: When I say throws, is it the same as bands or half bands? So a throw on the switch is a connection connecting to something. If it's connecting to the antenna port on a duplexer, it's to both the TX and the RX. If it's connecting to a TD switch, it depends on the architecture whether it takes two of them or one of them. You can do it both ways.

MODERATOR HA: So your definition of a throw is a number of switches?

MR. MUELLER: Well, no, it's the number of paths.

MODERATOR HA: Oh, okay.

MR. MUELLER: The throw is just how many --

MODERATOR HA: The number of paths.

MR. MUELLER: -- paths you have--

MODERATOR HA: Okay.

MR. MUELLER: -- through the switch.

MODERATOR HA: Okay. Number of paths, okay.

MR. MUELLER: And actually, again, I apologize for being an engineer, but there are other ways to build the switches where there are multiple paths possible.

MODERATOR HA: Okay.

MR. MUELLER: There are things like antenna diversity switches that complicate things yet farther, but that's probably a diversion and not useful to get into here.

MODERATOR HA: Gotcha. Any other comments or any comments on William's -- yes, Sumit?

MR. VERMA: I think I just wanted to add that, you know, we always wish to support as many bands as we can in our chipset, but unfortunately there are some limits to be mindful of. We have made some FCC filings regarding, you know, the limitations that do exist in this regard.

And I just want to quickly say, unfortunately, having this be two FDD Band Plans would appear to be problematic from our end.

MODERATOR HA: Okay. Christian?

MR. BERGLJUNG: Yes, thanks. On the number of bands in general, of course, it's a good thing that we can allocate more spectrum, but if possible to harmonize spectrum, if this band plan gets devised below 698 to have global harmonization in mind would be very beneficial, because that would limit the number of new bands and that would also promote interoperability and roaming possibilities with other areas. We think that was very important to keep in mind when we devise the band plan.

And then in terms of the number of bands, etcetera, that we may operate in bands that we may specify for the range, for this one on the 20 MHz range, we also need to bear in mind that we will also need receive filters for downlinks, etcetera. So that would also be added to the count of components that you need to account for in your spectrum plan.

So it's the number of filters and components that would be important.

MODERATOR HA: Okay.

MODERATOR HELZER: I'm sorry, I didn't quite understand additional receive filters? You mean for diversity path or you just mean as part of the duplexer? I'm confused. I didn't quite understand what you are saying about additional receive filters.

MR. BERGLJUNG: Sorry if I wasn't clear. That related more to supplementary downlink.

MODERATOR HELZER: Oh, okay.

MR. BERGLJUNG: You would also need filters along the receive pass for these types of events. Thanks.

MODERATOR PETERS: So I wanted to maybe hear from the operators on the panel regarding, you know, as Christian and others have said, adding more bands to a device adds components and generally adding components adds losses to the path.

And from an operator point of view is there a limit? Is there a point where you say, you know, I need to limit the number of bands, so that I, you know, don't degrade my performance past a certain point. I'm not sure if any of the operators would like to comment on that? Rick?

MR. ENGELMAN: Thank you. I'll ask Craig Sparks to speak to that. Thank you.

MODERATOR PETERS: Okay.

MR. SPARKS: Certainly. We do that all the time. Generally what we have is a set of core bands that are important to us. They are, you know, our home base. And then we have the roaming bands, you would almost call them like a priority two. And then you rank them in order. It's a triage conversation with the OEMs.

The problem is, that's if we were having one-on-one discussions with them about making phones just for us. What we find ourselves, increasingly, in modern days is they want to build single SKU, single hardware SKUs that they can sell to multiple operators.

And so, you know, we can complain. I can prioritize the bands. They play a game of like squishy water balloon. You say well, if I throw this band, then you are going to lose, you know, 2 dB up here at your higher bands and I'm losing antenna volume. And, you know, it's what are your priorities?

And in the end, you are chasing each other around and a lot of these conversations with some of the key OEMs that try to take that model, it's their call in the end. You have minimum 3GPP performance specs and a lot of times many of us, as a carrier-perspective, try to exceed those, by a good margin.

We are losing that margin as we are adding more and we are going to be backing right up to minimum performance specifications. It is a never-ending battle.

MODERATOR PETERS: All right.

MR. SPARKS: And I think adding 600 will be one of those inflection points, again, where they say you are going to be eroding, you know. We are going to be coming back towards minimums.

MODERATOR PETERS: Thank you. Karri?

MR. KUOPPAMAKI: Yes, just one other thing. I just want to go back to my previous comment on technology evolving and that's what we count on. So, you know, a few years back, if you look at phones, they may be supported 2 or 3 Bands at most and today, you know, 5, 6, 7 even in some cases. So the number of supported bands is just going up all the time.

And like we heard the switch is, you know, probably not the weakest link in the equation. There are other parts that need to be looked at, but every year the number of supported bands seems to be going up and it has been very beneficial for us.

The spectrum landscape is getting more fragmented, but at the same time, the technology evolution will take care of that for us. So I think that's something that we should also keep in mind and rely on as part of this.

MODERATOR HA: So I have a follow-up question maybe for QUALCOMM. In the FCC, we are trying everything we can to minimize the fragmentation of the spectrum, but sometimes it is kind of inevitable to get the spectrum on time, given the demands and so forth. So I think you mentioned that it's a little problematic having two bands with two duplexers for 600 MHz.

So maybe you can elaborate a little bit that it seems like we are not really arguing on what technology can support as a single band. I think there is some limit, whether it is 25 or 30 MHz. I think there is a good boundary right there.

But suppose we clear -- we end up clearing more spectrum and there is more spectrum available, then the path we are taking is there is optimum bandwidth that technology can support and that's the band that you want to put into your phone.

But the additional, the remaining spectrum may have to be allocated as a separate band or you just take the whole thing and put two duplexers, call it a single band. But isn't that kind of cost the same phone architecture you're going to have on the other duplexer at the end of the day or are there some other trade-offs that we should be aware of?

MR. VERMA: Okay. I think I would like to take a crack at that from a couple of different perspectives. I think the way we kind of arrived at the 25 MHz limit in this specific case was sort of really, I want to say, like a perfect storm with three things coming together. Right?

One was the 4 percent filter bandwidth, right? The second was the fact that the uppermost 25 MHz happened to be the cleanest from a harmonic perspective, so there was no fungibility issues.

And third was that was probably -- while again we admit there is some antenna pain, it was kind of the limit of which an FDD Band Plan would be maybe within tolerable pain of antenna limitations.

Now, to more directly respond to the question you had, there is, in addition to the 600 MHz Band, other low frequency bands that are needed to be supported. And so there is a limit to which how many of the bands can be supported at the same time.

If there are two 600 MHz Bands, yes, in principle one could look at them as just another band and what's the difference, but there are already a fair amount of existing bands to be supported. And so that's where the real challenge arises. You know, it would take away from another band somewhere else as well, in addition to the other technological limitations and issues that we mentioned.

MODERATOR PETERS: Okay. Thank you.

MR. VERMA: Thank you.

MODERATOR PETERS: We've only got a

couple minutes left and, Prakash, we will get to you in just a second.

I wanted to just point out, you know, in this panel and the previous panel on antennas, we have sort of two forces that seem to be driving toward a limitation in the amount of bandwidth that might be supported.

So one is the filters as we were just discussing, more bandwidth means more filters and it comes with the cost that we have been discussing. Also, the antenna.

And one of the questions I would like the panel to think about is which is the priority? Which is the more constraining of those two factors? And with that, Prakash?

MR. MOORUT: Yes. So I just wanted to go back to the question we had before on the number of bands supported. I mean, some of the devices out there, I think, support seven bands right now and probably in 2014 we can get up to maybe nine bands, just to give you some idea.

MODERATOR HA: Thank you, Prakash.

Harold?

MR. FELD: Yes. Two quick observations. One is it seems to me that the experience in the 700 MHz standard-setting process suggests that whatever official band plan the FCC may come up with that the standard-setting bodies may, by default, end up resetting some of the planning here, depending upon some of these technical challenges, particularly with regard to some of these other things.

Like even if you have got to reclaim spectrum natural license size and the ultimate distribution of the licenses after the auction, which raises some challenging questions with regard to if you want to actually make it harder for standards bodies to subsequently fragment the band post-auction.

You know, I'm just trying to think through these based on experience, but the other is is it okay to raise questions about revenue maximization, because a lot of the issues that are being raised here point to some implications to band plan with regard to the auction that have some significant implications.

And this will sound crazy coming from me for anybody who knows me, but if I were to pretend that revenue maximization was actually the primary goal of the auction, there are some very interesting outcomes depending on how you weight these factors here that may point to some very counterintuitive results.

MODERATOR PETERS: Interesting. Thank you.

MODERATOR HELZER: I think part of the answer we will probably come back to in discussion of those points in the trade-offs.

MODERATOR PETERS: Yes, on the trade-offs panel at the end.

MODERATOR PETERS: Yes. But we are running out of time, so, Christian, why don't you wrap this up here?

MODERATOR HA: Neeti is --

MODERATOR PETERS: We will get to

Neeti, too.

MR. BERGLJUNG: On the number of operating bands that we need to specify for this, again, I think our ultimate goal here and that's also with regard to maximizing revenues, etcetera, is to try to allocate 120 MHz of spectrum.

And regardless if you do that with an FDD Plan, a TDD Plan or the supplementary downlink, I think we are looking at at least two new operating bands.

I would like to remark that when we specify a supplementary downlink band, that's also an additional operating band in this 3GPP specification that will require considerations when we specify that type of band.

So I think we should bear that in mind and so that at least two operating bands, I think, we are looking at here for 120 MHz range.

MODERATOR PETERS: Okay. Thank you. Neeti?

MS. TANDON: So you asked -- again,

I'll give the operator's perspective on --

MODERATOR PETERS: Could you get the microphone? Thank you.

MS. TANDON: So you asked to give an operator's perspective on the number of supporting bands that we think is the limitation and that's a question that we juggle with on a very regular basis.

MODERATOR PETERS: Yes.

MS. TANDON: And basically, it starts with what can be supported in chipset and not just there, because the chipset is defined by low, medium and high bands. So there is a limitation on the number of low bands and a limitation of high bands and so on.

So besides supporting all the legacy bands that we have spectrum for in the U.S., we also have to support bands for roaming.

MODERATOR PETERS: Yes.

MS. TANDON: And to make matters much more complicated, you have a separate set of bands for in-bound roaming and a separate bands for out-bound roaming.

MODERATOR PETERS: Yes.

MS. TANDON: And as we already know, you know, we have added WCS to our portfolio and we are coming to deploy 700 D-Band, so that's a lot of bands to be added to the devices. And we can't keep up with the space, you know, that is being afforded by the chipsets.

MODERATOR PETERS: Yes. Okay. Well, thank you very much. With that, I think that is going to conclude our discussion on filters.

And we are going to move to the technical flexibility topic now. Bob, do you want to switch with Michael?

MODERATOR WELLER: Sure. Do you want to switch?

MR. HA: It doesn't matter.

MODERATOR PETERS: So sorry, it's easier. So Bob Weller will be co-Moderating on this one.

So I think as you heard Ruth Milkman this morning talking about the five policy goals, one of them was certainty. And one could argue that certainty in terms of defining what part of the spectrum should be used for FDD uplink versus FDD downlink versus supplemental downlink versus TDD, those types of decisions and rules could lead to more certainty, but also more rigidity with how the spectrum might be used.

And the topic of this next panel is to, you know, discuss those types of issues and how a band plan should be configured in terms of, you know, how sharply it is defined.

And one of the things -- maybe we will start with an issue that, you know, may very well come to pass, which is that part of the spectrum, at least part of it, is very likely to be unpaired.

And in that context, unpaired spectrum might be used for TDD or it might be used for supplemental downlink.

So the question to the panel is, you know, what technical rules would we need to add or modify or state in order to allow either option and can they coexist in the same unpaired part of the spectrum?

Anybody want to take a stab at that? How about Rick?

MR. ENGELMAN: Thank you.

MODERATOR PETERS: There you go.

MR. ENGELMAN: So I guess I'm going to have to understand the question a little bit, but maybe I'll put it in terms that work for me, if you don't mind.

Clearly, certainty is an important factor. I think we, everyone in this room, would agree that it simplifies life. I think it -- as an operator, we all want flexibility as well and so there are some trade-offs between the two.

You know, as an advocate for TDD and I think we advocate the last plan, which doesn't have it in part of the band, but would have it in the whole band, we think there is a lot of reasons why to do that and we think there is a very simple structure, regulatory structure to make that kind of scenario work and that's in our comments. We can talk about it if you want.

But I think the question you are asking is what about a scenario where you have a mixed environment? And I think I guess the way I would start looking at that is in our plan for a full band TDD, we had to deal with an existing lower band, lower 700 Band A Block uplink at the top end of the band. And the way you solve issues in that kind of situation, the easiest, simplest way is to come up with a guard band to provide separation.

It does take away some of the spectrum and the usefulness of the spectrum. At the same time with TDD, you don't have a duplex gap to worry about, so, you know, there are trade-offs on that.

I think the other issue, that if you look at that kind of plan, is looking at how do FDD licensees coexist with other FDD licensees or potential TDD licensees? And this came up before lunch as well. And the way TDD works, the way the standards work is there are a couple of parameters that go into determining when you transmit on the uplink, when you transmit on the downlink and how often you transmit on the uplink and downlink.

And those parameters are defined within the standards. They are -- if operators agree to those parameters, the interference consequences are significantly minimized. And there is great incentive for operators to do that. In fact, there is also great history where operators have done that at 2.5 in the US. There is, a number of different operators were beginning to roll out WiMAX TDD services years ago.

It took only a matter of a few months for the operators to agree on uplink/ downlink ratios and to agree on synchronization. And that has existed and stayed in existence and worked fine for six years now.

So those are things we think can be done. The question was asked earlier, how do you get the operators to agree? I think the market drives the operators to agree, because the alternative is you need guard bands. And guard bands are an inefficient use of spectrum. I think this is very valuable spectrum.

I think a possible alternative that would be for the Commission to -- there is only two parameters really, two or three parameters to the Commission, that needs to be decided and that's the uplink/downlink ratio. And to some extent, the timing gap that allows -- determines what is the range of the cell site? How far away can it serve mobile devices?

The number of choices within those two parameters are also rather small, fewer than 10 options, fewer than 10 choices on each of them. So the Commission could, in its infinite wisdom as well, pick a default and give the industry the opportunity as well to negotiate if something is different. That would be an option, not one I necessarily have commented on or we have commented on in favor, but it is an option.

We do think the marketplace will drive people to agree, it has. And, you know, we think the benefits of TDD, you know, in terms of its flexibility to deal with the band plan, its ability to -- its simplicity from an interference perspective. The fact that it can be -- we haven't even talked about data asymmetry, but the fact that it would be -- can very efficiently be configured to deal with the uplink/downlink that occurs in the marketplace with data, those are all things -- and the fact that it can enable instant new entry by a new competitor.

You don't need to have to find both downlink and uplink spectrum. You -- once you get a TDD Band, you can operate from that point. Those are all things that I think make it strong. And so these issues -- it's a proposal.

So these issues on what are the regulations we see are really, in our minds, things that are easily accomplished.

MODERATOR PETERS: Thank you. How

about George Harter, Clearwire?

MR. HARTER: Thank you. I almost turned my card back down, because Rick, you know, said things so eloquently there. Let me just try and reinforce a little bit of what he was saying.

I mean, Clearwire has lived this for about 10 years now, right? It's an interesting case study when you look at where we were, where we started, the uncertainty that we faced in the allocation of spectrum, the different protective service areas within the EBS/BRS Band. We had to deal with all that.

And the way we dealt with it was we chose TDD. TDD gave us the flexibility to move within the band when channels weren't available or there were other operators that we had to deal with. We could easily move back and forth. And quite frankly, that flexibility was key to our success.

We reached a point in time where we were, you know, going towards LTE, so we were looking at -- we actually looked at what's the right technology? Should we keep going TDD or should we go FDD? And we actually did some testing. We looked at kind of the band -- 38 Band 7 type of an application.

Rick is right, you do need some guard bands there. It was quite interesting. The base stations are pretty easy to do, right. You can get filters and design reasonable filters to get fairly low in terms of guard band.

The UEs, it takes a reasonable amount of guard band there and I say that because we even tested our WiMAX UEs which are broadband, there is no filtering. They are not like 3GPP defined Band 37 Band 7. And they worked well until you got into what we call the Starbuck's environment, right?

Where you got in very close proximity and you had issues with interference between FDD and TDD. So that's just a little bit of history there.

But we ultimately chose TDD as the proper technology for us. And again, it gets right back to the principles that the FCC has outlined: Flexibility, certainty, interchangeability, quantity and interoperability. All of those can be met with TDD technology.

And I'll just reinforce what Rick said about synchronization. Letting reasonable operators figure out amongst themselves what is the right TDD ratio between them is something that is very reasonable and we have been doing it for years.

Let's face it, we are not trying to do applications that will drive significantly different TDD ratios. The ratios have been clearly defined in 3GPP. You can choose from a few.

We currently do a ratio that is, approximately, 3:2, downlink to uplink. We find that that's very beneficial because, one, it does give us the weight that we need on the downlink in terms of capacity and throughput, but it also balances the link budget because TDD is typically uplink limited, so there is kind of a trade-off there.

And having the additional capacity on the uplink is beneficial in applications, especially when we get in situations where you have users driving applications that need a lot of uplink bandwidth.

So again, we don't think it is difficult for the FCC to allow the industry and allow operators to work together and pick the TDD ratio that is appropriate for their markets and applications.

MODERATOR WELLER: I think we had -- thank you for that. I think we have a couple more folks here. Christian?

MR. BERGLJUNG: Yes. Thanks. In our reply comments we provided two alternative plans: An FDD arrangement with two operating bands and a TDD arrangement, also with up to two operating bands.

And of course, the latter if -- were the Commission to adopt such a plan with adjacent blocks, fungible blocks, that would require synchronization between the operators. So that will be a thing that we will need to take into account. And then whether or not that is possible, that needs further assessment.

When it comes to mixture of different technologies, having the Band 7, which is an FDD Band, and Band 38 discussion in 3GPP in mind, we would definitely advise strongly against such an arrangement.

As George just mentioned, these bands were, of course, specified much earlier and then in 3GPP, we were quite late in setting actual requirements for these.

And unless you are prepared to accept the degradation in the -- in your Starbuck's environment, you will need a quite substantial guard band on the order of the assigned channel bandwidth. That is an – and even larger to meet the 3GPP standard requirements for UE to UE co-existence in the Starbuck's environment.

So we would -- from that experience

in 3GPP advise against the mixture of the technology, so it should be either in our view -- either two FDD Bands or TDD plan adopted. Thank you, sir.

MODERATOR WELLER: Interesting. I think we probably do want to come back to the issue of mixed technologies, but let's finish out the group here, Prakash.

MR. MOORUT: Yes. So I actually wanted to comment on the issue of mixed technologies. I think we have heard about, you know, how you can coexist, you know, make two different TDD systems coexist by synchronizing and making sure you align your downlink and uplink split so you don’t have them operating next to each other.

On the mixed technologies, you know, the guard band alone is not enough. I mean, you need filters. So if you have the TDD, you know, next to the downlink, if you take the down from 51 hybrid scenario where you have a downlink and what you call various and in various you have TDD, next to it is downlink.

So if you have the FDD Base Station, it could interfere with the TDD Base Station. So you potentially need a guard. The guard band, you know, will serve as roll off for your filters. Like you need probably filters on your FDD downlink and then you need a filter also on your TDD receiver. So the guard band alone, you know, it's not enough.

On the device side, I mean, I agree with Christian, that's tougher. So some of the techniques that 3GPP has looked into for Band 7 and Band 38 was, you know, to do a required additional maximum power reduction, for example, so you knock down the UE transmission by more than you usually do, to mitigate interference.

And then also looking at, you know, where you would move uplink control channel further away from each other's edge, so like you don't have issues with the uplink control channel.

So it's not -- you know, it

definitely gets more complicated, but at the same time, you know, it has been done for Band 7 - 38. So there are trade-offs that need to be looked into in more details. And this is 600 MHz. It's not 2.5, so the guard band size probably would be different. We need to figure out how much it is.

But the other caution I would put is just putting a guard band without all these other measure, filters and, you know, special mechanisms on the UE side, you know, it is not enough.

MODERATOR WELLER: Okay. Thank you. It sounds like TDD would have some unique impacts on wireless medical telemetry. Delroy? Yes.

MR. SMITH: Thank you very much. Yes, as you know, I just want to correct the record a little bit from prior -- this morning. Channel 37 used by telemetry is a Part 95 Licensed Service to us and so there are some responsibilities there.

You know, clearly, those older systems were not as flexible in their development and design. And so when one thinks about well, how can one really accommodate health in this situation, one -- you know, we would like to still maintain the white space mask that was agreed to. And hopefully the other parties can achieve that.

But there may be situations where you can't achieve that level of protection. And so then the flexibility comes in to the types of neighbors that we have to work with. You know, we could -- there could be neighbors where we can do things like coordination.

So instead of applying a technology-based solution, you could apply a more coordination rules-based mechanism. You know, if the neighbors aren't too numerous, then it's easier to manage and so forth. You know, so those are some of the things that you may want to think about as you formulate and finalize on the planning, you know.

MODERATOR WELLER: Okay. Harold,

I'm going to come back to you. Sumit?

MR. VERMA: Thank you. I think for starters, I think what I want to say is that, you know, we build chipsets that support FDD and TDD technology. So from that perspective, you know, we don't have anything to gain in terms of anything other than just speaking to the facts as we see them for this particular band.

We do believe TDD is a great technology for Band 41 and the higher frequencies and, obviously, it has a lot of benefits. But for 600 MHz applications for some of the reasons that we have been kind of touting, specifically having any kind of uplink whether it is in the form of a second FDD Band or in the form of TDD in the lower frequencies, causes issues for guard banding. It causes issues for harmonics that fall into protection bands, therefore, causing CA issues.

And then certainly if you have a mixed set of technologies that causes additional challenges, it has been noted. So again, in general, we believe TDD to be a great technology. But in this specific application of 600, we don't necessarily see that as the best place to deploy.

MODERATOR WELLER: Okay. Karri?

MR. KUOPPAMAKI: Thank you. Yes, I just want to thank Christian on his comment that you should not mix FDD and TDD if there's extra spectrum, and then we do agree with that. And that is because of the guard band that is needed in between the two.

And as mentioned, the guard band, of course, it is -- you know, can be very, very wide depending on the bandwidth that is allocated for TDD. And in a TDD-only band plan, you still have that same issue because you have FDD, the 700 Band, right next to that. And then the guard band immediately in between would be equal or even bigger than the duplex gap required in an FDD arrangement.

And then also I would like to comment on the benefit of having supplemental downlink spectrum. The environment we live in is changing. You know, there are more and more downlink graphics. The video is the application that is really consuming most of those resources and it's just getting more and more or bigger and bigger.

And consequently having supplemental downlink spectrum has its benefits because of the asymmetry between uplink and downlink that we only see getting bigger and bigger in the future.

So all that combined, I think, if there is extra spectrum, it certainly makes sense to allocate it in a supplemental downlink basis, rather than try to mix and match TDD and FDD in the same plan.

MODERATOR WELLER: Okay. Darryl?

MR. DeGRUY: Yes. I agree with what Karri has said. We are -- US Cellular owns quite a bit of the lower A Block spectrum and the lower 700 MHz, so obviously we wouldn't want to see impact from TDD impacting that spectrum. I think we have enough concerns in the lower A Block already.

Another thing I wanted to question is we speak a lot of the symmetry of traffic and how today video is driving downlink to be a significant use of traffic, but things change quickly. And there is a company out there called Google that is coming up with Google Glasses and the ability for people to post and record things and push them up to the cloud and things change over time and applications change over time.

So flexibility is probably important in being able to address those changes.

With that I see carrier aggregation is a good way with the FDD technology to adjust and be flexible to those changes if we are able to aggregate different bands or intraband to allow flexibility within the design.

I'm somewhat ignorant, I'll say, to the ability to carrier aggregate TDD simultaneously to FDD, but I -- my guess is that is not possible today. I don't know if that is looked at in the future. And I would like to hear comments about the ability to support flexibility if TDD were chosen for carriers who have a widely deployed 4G, LTE, FDD network already. Thank you.

MODERATOR WELLER: All right. Jignesh and then Harold.

MR. PANCHAL: Okay. Hi, this is Jignesh Panchal from Verizon. I think we echo US Cellular, T-Mobile, QUALCOMM's comments there, especially in the microcell deployment environment. We worry about TDD co-existence issues, TDD-FDD co-existence issues, especially -- you know, we have seen studies by Nokia Siemens where they require -- they suggested that we need up to 12 MHz of separation. And that is basically at 2.5 GHz.

Now, if you go down to 600 MHz because of propagation differences, that megahertz difference is increased actually. And, of course, you know, Darryl mentioned about the specific uplink and downlink ratio which is -- you know, which can change, so we need some sort of, you know, dynamic inter-operator synchronization, uplink/ downlink synchronization, which is difficult to do.

MODERATOR WELLER: Thank you. Harold?

MR. FELD: Okay. Just a couple of quick things. First, I would observe that actually one of the advantages of white space database technology is it is actually both a technical solution and a cooperative management solution. So to the extent that we are looking at the flexibility of use either with regard to TV white space and operations within the band including potentially your -- you are potentially operating on Channel 37 or even with regard to licensed operators for which coordination with Channel 37 might be necessary, the -- you know, that may provide one potential solution.

You know, with regard to the trade-offs on TDD, I think, first, I want to very strongly reiterate the caution from US Cellular that use patterns change dramatically and really rapidly. And that one of the disadvantages of going to a supplemental download scheme, which would tie up licenses in these supplemental download links is that that locks in particular technologies.

We are seeing on the wireline side a growth in symmetric traffic as users become -- they have more devices enabled and particularly also as photographs and video obtained through mobile are then, you know, off-loaded through Wi-Fi rather than trying to use the mobile licensed network.

So I would very much caution against, you know, a reliance on today's traffic patterns for -- as a predictor of the future. In keeping in mind the question of what spectrum might be wasted on guard band size versus say duplex gap for an FDD, it is important to remember that what we are talking about is the total space unavailable for licensed use overall.

And that, therefore, when looking at

the advantages of an all TDD Plan versus an all FDD Plan versus a mixed-use plan, it is important to be mindful of the trade-offs in this regard and not just focus that some have and say well, it would require a huge guard band between the 600 MHz service and the 700 MHz service, but it might be worth the trade-off depending on other efficiencies that are gained in the band plan or it might not be worth the trade-off if it turned out that a smaller guard band between 600 and 700 in a modest duplex gap turns out to be a superior use.

MODERATOR PETERS: Harold, on your point about rapidly changing usage patterns and uplink/downlink ratios perhaps changing, isn't that maybe an argument toward TDD, rather than FDD in a fixed bandwidth?

MR. FELD: That element of it certainly supports TDD. The question of whether FDD systems are going to be more easily integrated into existing carrier architectures is -- you know, may potentially weigh against that. It is one more factor to evaluate.

You know, if we -- if this were the only band, then -- and we wanted to maximize flexibility, then, yes, TDD would clearly be superior in that regard. But it's not the only band and one of the big differences actually that I think we ought to reflect between this auction and the 700 MHz auction is that band plan design in 700 MHz auction was in part motivated with the effort to entice a third-type -- new provider to enter into the market.

At this point, I don't think anybody has that illusion. This has been marketed, if you will, to Congress and throughout as being supplemental to existing carrier architecture, even if we had a new entrant in the form of DISH, they would not be looking to be a new entrant with regard to radically different architecture and purpose. They would be looking to fit within the existing architecture.

MODERATOR PETERS: Okay. Thank you. Neeti, did you have some comments on TDD?

MS. TANDON: I'll just be very quick. One point that we have not brought into consideration here is to your earlier question on co-channel. If it's TDD, then you are always looking at the separation distance from your TV broadcast station. So it makes the band plan a little bit more difficult to implement.

MODERATOR PETERS: That's a good point. Thank you. Christian?

MR. BERGLJUNG: Yes. Thanks. Just to comment on the use of the spectrum below Channel 37 for uplink be it either with an FDD arrangement or by direction of TDD. We also think that the traffic pattern may support such an arrangement, so that we should make sure that we have sufficient uplink spectrum.

The operators may be able to correct me, but I think at some sports event, for example, the uplink traffic is even larger than the downlink traffic, so from that aspect, we think that it is good to also try to maximize the number of the uplink spectrum.

And we do not think that harmonics should be the show stopper for that. And as far as we are concerned, there is only -- we talk about harmonics in to GPS L5 at 1176 MHz or, I think it is, a fourth order harmonic into the WCS Band. And I think those are technical issues that we can deal with comparing to the need for increasing uplink spectrum.

And also when it comes to fungibility of the spectrum, we think that that has benefit to try to increase the uplink spectrum as well.

And lastly, we were discussing flexibility. Of course, the big flexibility happening for FDD is in carrier aggregation. As AT&T pointed out, there are other bands which you can -- that you can aggregate. And TDD operators can play with the uplink/ downlink ratios. There are a number of different configurations that are available in the standards for doing that.

MODERATOR WELLER: Yes, Chris?

MODERATOR HELZER: Christian, if I could just follow-up for a second? I guess

Darryl had asked earlier is aggregation of TDD and FDD supported easily or not easily? Because somebody else may have answered that, but if so, I missed it.

MR. BERGLJUNG: It is not specified now currently in the specification, but there are proposals in 3GPP for specifying FDD, TDD carrier aggregation.

MODERATOR WELLER: Rick, I think we skipped over you and then Delroy and Karri.

MR. ENGELMAN: Okay. Well, a couple -- a number of things I want to respond to. First, Darryl raised the question as to what operators that have deployed FDD on a wide scale basis are also interested in TDD? And so I guess my first comment is does anyone have a handset here that doesn't have Wi-Fi in it? Because if you have a handset without Wi-Fi, you don't have TDD.

But if you have Wi-Fi, you have TDD. As far as I know, every operator supports Wi-Fi, so every operator already considers how to deal with TDD within part of their network.

I think another point is Sprint certainly is deploying FDD, LTE and a number of bands. Sprint and associates from Clearwire is looking at TD-LTE in Band 41 and Sprint has said we would be interested here.

We see the opportunities and advantages of both bands and I think just as most operators want to have spectrum in different bands to meet the needs of different service areas and different environments, I think the technologies also lead you to different choices in different situations, that's not an issue. It's not a hurdle. It's an opportunity.

I think also the gentleman from Verizon asked about dynamic changing of uplink and downlink. I don't think that is something we would envision. Clearwire chose the uplink/downlink ratio along with other licensees six years ago. It hasn't changed. It hasn't needed to change. I don't -- you know, there is an opportunity perhaps with some technology down the road to look at it, but that's not something I think we would advocate or even think about, at this point.

The other point is one I would like to follow-on, I think it was Christian that was talking about it, in terms of FDD. If you pick supplemental downlink, it's essentially equivalent to trying to make up for the defaults of a paired FDD Plan. The fact that it doesn't match the traffic and so you are doing supplemental downlink to try to take a technology and make it something that it isn't.

And the consequence of that is you are losing the opportunity for competition. This is really, really important that we have competition for spectrum below -- an opportunity for spectrum below a gigahertz.

Right now, two licensees hold upwards of 80 percent or more of the spectrum below a gigahertz. It gives them huge opportunities that other operators in the U.S. do not have in terms of reaching coverage and reaching in building.

It is very important we have the opportunity in this band for maximizing the competition. And to do that, you need the ability to transmit both uplink and downlink directions. I think with that I'll stop.

MODERATOR WELLER: Thank you. Delroy?

MR. SMITH: Yes, so I just wanted to comment on my neighbor's comment relative to -- and also the Commission's thoughts on putting some devices in Channel 37, I think in white space device and so forth. You know, that's an area of concern for us, because these -- the systems -- we may have several hundred thousand devices out there that are -- once they are put in a patient, they are running continuously 24/7.

Even if you just had a 1 percent error in detection rate, you are talking thousands of patients that could be at risk of not getting their alarms and so forth. So that's a concern.

It doesn't mean that it's impossible

to work that way. I think, you know, again, you have to be careful in terms of, you know, how you do that, what sort of protection mechanisms you would put in place, what sort of, you know, exclusion zones might be enacted to manage those types of situations.

You know, so that's -- I just want to alert you that it's a troubling area for us and we would really need to study it carefully to make sure that, you know, the patients are well-protected and so forth.

MODERATOR PETERS: Thank you. I have a question for the panel regarding the choice of supplemental downlink versus TDD. Certainly a new entrant could use TDD, but it would be more challenging for a new entrant to use supplemental downlink because there would be nothing to aggregate that with in order to provide an uplink.

But that brings me to the question of for supplemental downlink, are there -- what are the challenges? What bands can that be aggregated with? In other words, are there certain challenges to aggregating it with cellular versus PCS versus AWS versus 2.5 versus 700? Which, in other words, spectrum would an operator need to hold in order to make efficient use of supplemental downlink spectrum in this band? Does anybody have a thought on that? Sumit was first.

MR. VERMA: The way we had envisioned the use of -- when we made the antenna arguments, it was with the assumption that you would not want to have that low band antenna be simultaneously operating at 600 in another low band. So that is a strong case to say you really don't want a CA with another low band here.

MODERATOR PETERS: Yes.

MR. VERMA: And so that leads to the fact that the best CA would be above 1 GHz for 600 MHz. And, yes, thank you.

MODERATOR PETERS: Christian?

MR. BERGLJUNG: Yes, thanks. For the supplemental downlink similar arguments here that we would like -- we would also make perhaps from a multiplexing issue. If you would multiplex a supplementary downlink band that is right next to, for example, a paired FDD for example, that would also -- may also at least from a 3GPP-perspective raise new architectures that we have not considered with two adjacent pass bands.

However, a supplementary downlink portion could, of course, be combined with a high band, something above 1 GHz.

MODERATOR PETERS: So you agree with Sumit that it --

MR. BERGLJUNG: Yes.

MODERATOR PETERS: -- would be practical to bond 600 MHz supplemental downlink to 700 or to 850?

MR. BERGLJUNG: Yes.

MODERATOR PETERS: Okay. Okay.

MODERATOR HELZER: So just to follow-up on that a little bit, it sounds like both of you are saying 600 is a lot easier to aggregate with a high frequency band. Does that kind of devalue the supplemental downlink? Does that cause you link budget problems, because 600 would be thought to be very valuable because of the good propagation, but if you have to pair it with a band with much worse propagation, does that kind of devalue the supplemental downlink? If anybody wants to comment on that? Rick?

MR. ENGELMAN: Thanks. That's actually the point I wanted to make is, you know, the real benefit of the spectrum below a gigahertz is this propagation characteristics. And when you dedicate that spectrum to downlink, that's actually the stronger of the two paths anyhow.

Ideally, and Ericsson said this earlier, the traditional band plans for mobile radio is to put the uplink on the lowest spectrum, because it's the one that is most problematic with getting through.

So if you have supplemental downlink and have no uplink at all below a gigahertz, then you really are constraining to that spectrum to being used with a shorter range, higher frequency carrier aggregation scenario.

So you are kind of taking spectrum that is really sweet for propagation purposes and using it more with the capabilities of the higher band. You are limiting it to that kind of range. It's not a particularly useful part of that.

And again, as we go back, we say it constrains. When you take spectrum away from something else and give it to supplemental downlink, you are taking it away from the opportunity for others to use it for that competitive basis.

So we don't see that as a good approach. Thank you.

MODERATOR PETERS: Darryl?

MR. DeGRUY: I also wanted to speak to supplemental downlink. If it is paired with other spectrum above a gigahertz, there are different fragmentations of who owns that spectrum above 1 GHz. So there becomes an interoperability concern over what pairing does that supplemental downlink get ultimately tied to in the high band?

If you are a carrier that doesn't align with that spectrum or doesn't have an overlay of the supplemental downlink, that is going to devalue it, because I probably will not bid on a supplemental downlink that does-- I don't have high frequency carriers to aggregate that with or to supplementally down -- or to link it together, I guess, is what I'm trying to say.

So it does cause some concerns not only from that standpoint of what licenses shall I bid on, but what do devices get built to? Does it get -- does the device get built to support supplemental downlink on PCS, AWS, WCS, 2.4, 2.5 GHz? Without some interoperability language to make sure that it aligns with what the carriers who are bidding in the auction, you know, they need to align that with their spectrum holdings to see the value of that.

MODERATOR PETERS: Thank you.

Jignesh?

MR. PANCHAL: I just want to comment on the -- you know, Rick said about supplemental downlink being the coverage layer and it doesn't fit well with the carrier aggregation with higher band. But in 3GPP currently there are studies where you are talking about UEs basically having dual connectivity to both, you know, high frequency band, which is in small cell environment, and connecting again supplemental downlink to the coverage layer at the low frequency band.

So there is a possibility you can have in future where you can still have coverage benefits of supplemental downlink, you know, along with the small cell high frequency link

MODERATOR PETERS: Okay. Interesting. Harold, please.

MR. FELD: Drifting back to the revenue, given that QUALCOMM suggested that you actually couldn't pair the supplemental downlink with the winners of the paired 600 licenses or probably not even with the -- any of the low band spectrum, that has really significant consequences of asking whether it is worth it just from a revenue maximization perspective, especially if you have to take up space that you would use for relocating other broadcasters that are not exiting the market, which is one of the sources of spectrum, in order to create supplemental downlink spectrum.

If you -- you also have the real problem of creating essentially two auctions. The auction for the actual good licenses and then the consolation auction for the supplemental downlinks. And I mean, maybe you get a revenue maximization auction by having the AT&T and Verizon auction for the good stuff and letting everybody else compete for the supplemental downlinks.

But I can't imagine that that's a favorable outcome.

MODERATOR PETERS: Sumit, do you have a response to that, because I don't?

MR. VERMA: I think, first of all, we would like to say that we see carrier aggregation and supplemental downlink as sort of something that is really being demanded of us to support and it is like the hottest -- you know, it's whatever one wants and we have to support it.

Our understanding, and of course not being an operator, it's just our understanding, is that the networks are heavily downlink limited as of today. Now, maybe that changes tomorrow, but -- or in certain specific applications, but generally speaking, that's our understanding.

And so for -- in that regard, we don't view the SDL, supplemental downlink, in 600 as sort of being a second tier. In fact, we see it as being highly desirable potentially for someone who would want to get more downlink coverage with great propagation characteristics. So we see that as a real boom -- boon, sorry.

And secondly, I do want to mention that the reason we strongly support a single FDD plan plus SDL is because that is also more feasible to support in the phone or in the UE with our chipsets. It is a lot more feasible than multiple FDD Plans or other sort of plans that have been suggested.

So from both what we perceive as the market needing and what is being demanded of us and for the real value the downlink has overall in the asymmetry of traffic, we see it as a -- that combination as being a winner from all those perspectives. Thank you.

MODERATOR PETERS: Okay. Thank you. Doug?

MR. HYSLOP: Yes, I agree with Rick's comments regarding the value of low frequency band spectrum. If you look at the competitive carriers, you really have access to very limited amounts of interoperable low frequency band spectrum and that is essential to controlling the economics, especially when you look at expanding coverage into lower population areas.

So to the extent we can increase the

amount of uplink spectrum that exists, particularly make it interoperable, that's what the competitive carriers really need to get access to in this next auction.

MODERATOR WELLER: Okay. Thanks. I'm not sure who is next. Jignesh?

MR. PANCHAL: I just wanted to add one more point from application point of view of the, you know, SDL. We can use SDL, for example, like -- you know, in applications like eMBMS where you just broadcast downlink. It doesn't require uplink actually, so you can use that as coverage extension of the broadcast application.

MODERATOR WELLER: Very good point. Christian?

MR. BERGLJUNG: Yes, thanks. We have -- in our reply comments, we only proposed two different arrangements with paired FDD and bi-directional TDD. And we think that that is good from a fungibility perspective in order that we don't preclude future changes of the traffic pattern.

And in this case, we have the possibility to do so. We, indeed, got one supplementary downlink band in the 3GPP specification and that's the media flow spectrum. And we did have various options for pairing that part with other uplink portions, but it was -- seemed that the supplementary downlink solution was the most viable to do in that case, in that particular case.

But it was considered by the 3GPP and we looked at various options for specifying that band. And we ended up with a supplementary downlink band because that was seen as the most feasible and that's, of course, still an amount of valuable spectrum.

However, we think that the situation is slightly different here for -- under this incentive auction for the 600 MHz Band and we think that we have the possibility to create either bi-directional or fully paired bands.

MODERATOR WELLER: Thank you. And, Karri?

MR. KUOPPAMAKI: I just wanted to make a quick comment on the -- you know, sometimes principle and practice don't meet one another and we talked about the flexibility of TDD in this context and some of the potential benefits over SDL.

But at the same time, you do have to have, as discussed, the same uplink/ downlink ratio across all the different networks. And different networks have different traffic characteristics and that's just the nature of the beast. And it is going to be probably in practice very difficult to change those uplink/downlink ratios dynamically, especially if you have multiple operators deploying TDD.

And then the other benefit of SDL in the low band especially, you know, it translates into stronger signal strength in indoor locations. And at home, for example, we mostly do -- I mean, the stadium scenarios may be a special case, but at home we mostly download stuff rather than upload stuff.

And then that would translate into a benefit of having better download speeds, better perceived experience in indoor locations and you don't necessarily need all that speed in the uplink direction.

MODERATOR PETERS: So your point, in other words, is so long as you are in a location indoors where you have enough signal strength to uphold the control channel of the high band, the primary uplink/downlink channel, then the downlink you are getting from the supplemental 600 will be more robust than it would be otherwise in a high band. Is that your point?

MR. KUOPPAMAKI: Yes, as well as the TDD not necessarily being as flexible as we think it is because of the practical challenges associated with changing the uplink/downlink ratios on the fly.

MODERATOR WELLER: Christian, one more comment. We would like to move -- okay. I think we would like to move on to a discussion of flexibility of use in the guard bands and that would include Channel 37, the duplex gap and all the other possibilities.

We have heard some suggestion that some additional filtering might be necessary to allow unlicensed uses. We heard a suggestion that maybe the white space model where there is database registration and authorization required in order to come up in the guard band, so that might be appropriate.

So what types of unlicensed services might be appropriate for use in the spectrum that is not licensed at auction? Harold?

MR. FELD: Well, obviously, a lot depends on the size of the guard bands and what the ratios are that are used for the handsets with regard to the expectations for their ability to reject unwanted signals.

The question to some degree is to say what consideration should drive what? I mean, if you were asking me how would I structure a band plan to maximize the utility of TV white spaces, you know, post-auction is something of a different question from, you know, other purposes in the guard band.

I think generally, from what people have been saying, there should certainly be no inconsistency with unlicensed use of guard bands. I think that the Channel 37 issues are workable and that because the community of operators within Channel 37 and the TV white space folks have worked together before to come up with mutually acceptable technical solutions, I'm optimistic that that can happen again.

I think that certainly narrow band machine -- the machine type communications should be possible in even the smallest potential guard bands, but ideally, guard bands that are for a variety of reasons large enough to support broadband use for broadband solutions should be usable in that for those purposes.

MODERATOR PETERS: I just want to point out that, you know for everyone's benefit, this subject in this discussion we want to focus on sort of the coexistence of operations in the guard bands and duplex gap with wireless services and sort of the larger subject of guard bands and how they are used and the size and other aspects of guard bands may become the subject of a future forum or workshop.

But I just wanted to make sure everybody was in line with the focus that we are aiming for in this particular workshop. Delroy, do you have a comment?

MR. SMITH: I am continuing this discussion with my friend next door. I'm kind of -- in terms of your proposal, what are you thinking of in terms of protection mechanisms to be able to operate within Channel 37 and afford us the protection?

MR. FELD: Well, I don't know that -- well, what I would hope is that not just me, because my organization is not the sole -- in fact, we don't actually manufacture anything. We are a public interest organization. My hope and expectation would be that actual manufacturers of the equipment and manufacturers of Part 37 equipment could work that out.

I suspect that there are solutions that would be available including limited geographic exclusion zones that are similar to what we used for wireless microphones or would have been proposed for, you know, the wireless microphones at event sites that would be able to screen hospitals.

I do expect though that as we are moving to a more intense use of wireless broadband within hospitals internally for electronic medical records and for the way those systems are tying in, there are actually synergies that suggest themselves as well potentially.

So all of that strikes me as a very rich conversation to occur off-line, rather than here. I would just add that, in fact, the larger concern to some degree is wireless microphone and their use, rather than -- and where they are going to go, rather than the question of TV white space devices which are already, at this point, fairly heavily -- you know, have pretty strict out-of-band emission limits and a variety of other controls.

MODERATOR WELLER: Any follow-up? Delroy?

MR. SMITH: You know, my biggest concern is risk, risk-management, which we have to do as medical designers. And I don't see a good risk-management piece here in terms of the mitigations and to be able to protect the patients effectively.

And again, it is -- you know, unlike a cell phone device where communications are continuous, we are one of the few devices that are absolutely 100 percent of the time continuous. And therefore, it really becomes a real challenge for other systems to coexist when you have to use a channel all the time.

You know, if it weren't like that, then you would have a slightly different probabilities there. But our probabilities really start to ratchet up because we are using the channel all the time. And so that's -- so we really need to be very careful to look at the detection -- you know, I mean, there is no testing that has been done relative to the database and so forth and the management and so forth.

You know, and that would require quite a bit of effort and risk-management that we would have to go back through. We are required to do continuous risk-management on our systems, so whenever a new threat comes up, we've got to go back and re-engineer that piece, so that's something that, you know, we would need to look at carefully.

MODERATOR WELLER: All right. Thank you. Christian?

MR. BERGLJUNG: Yes, thank you. With regard to unlicensed use in the guard bands, we would like to -- we strongly urge the Commission to go ahead and try to maximize the licensed spectrum first and solve the issues with regard to licensed spectrum.

And then after that has been done,

additional services could be considered for guard bands following studies. We think that that should be the order in which the band plan should be devised. And --

MODERATOR WELLER: I think our Congress would agree with you.

MR. BERGLJUNG: Yes.

MODERATOR WELLER: Some of them at least.

MR. BERGLJUNG: And with regard to the medical services in Channel 37, at least in the Ericsson comments for the Ericsson Band Plans, disregarding the status of this band in regulations, I think few of us would like to see interference into medical devices, because anyone of us can become a customer at the hospital.

So at least we should make sure that these services are not interfered with. Thank you.

MODERATOR WELLER: Sumit, you were next.

MR. VERMA: Yes. Just as a general comment, I know we touched on the size of the duplex gap as being as narrow as possible, you know, 10, 11, 12 MHz. And then also guard band between -- oh, yes, you do. Okay. Actually, so having said that, my colleague, Kent Walker, is actually our subject matter expert, so I would actually like him to make the real comment here. Thank you.

MR. WALKER: Thanks, Sumit. Okay. I have to make a pitch for QUALCOMM. We sell technologies for both of these, so, you know, don't -- nobody should take anything personally. We are happy to sell hardware.

So we have done some exhaustive analysis in this area and given the structure of the bands that we have indicated in the order of 10 MHz gaps or duplex or TV, if you put white space in those bands, you will cause mutual interference between the services. It is not avoidable.

Okay. The issues basically come

down to the filters aren't good enough. Okay. And we have said that in our comments. Another area on which this poses an issue is we would expect this sort of thing to be a widespread deployment. And the medical application is relatively contained and so the impact on the adjacent spectrum is at least geographically limited. In other words the fungibility problems have limited scope.

As Sumit was just getting ready to state before I interrupted him, the way to fix this is to say hey, okay, let's put 10 MHz on either side of the white space signal, which if we do in the duplex gap, explodes the issues that we just flogged about the antennas. So there is another issue.

And if you follow that line of thinking, all of this just decreases your auctionable spectrum, which is one of the things you are supposed to be maximizing, so that covers our bit on it.

MODERATOR WELLER: Let me ask a

follow-on.

MR. WALKER: Sure.

MODERATOR WELLER: You said the TV white space would cause mutual interference?

MR. WALKER: Interference, yes.

MODERATOR WELLER: TV white space really isn't one thing. There is 4 watt devices and there is 40 mW devices and we have different --

MR. WALKER: It's all -- yes. It's all a matter of degree. Depending on the rules and depending on how far away you are. I think we have multiple use cases in our filing, but if we don't, we can follow-up with that.

MODERATOR WELLER: So in your view is this manageable in some way or is it beyond hope?

MR. WALKER: I would be more of the latter and less of the former.

MODERATOR WELLER: Okay.

MR. WALKER: It's -- you are going to cause problems and it is a matter of degree.

MODERATOR HELZER: So just as a

follow-up, I hear you talking about, you know, what 10 MHz and so forth. I don't know. I remember a long time ago when I was working on 2 GHz stuff, people were saying they needed 5 to 10 MHz separation between handsets.

Now, we are talking about something that is much lower power like a TV white space device and we are at one-third the frequency, so we should need only one-third type of roll-off, because generally, duplexers, filters, SAWs, they are all a percentage of the bandwidth.

So I would think people would be talking about 2 to 3 MHz guard bands.

MR. WALKER: Yes.

MODERATOR HELZER: And similarly, like Sumit just referred to a 10 MHz duplex gap is the smallest possible and yet we have a 15 MHz duplex gap in Band 25, again at 2 GHz, so you would think the smallest possible would be closer to 5 than 10.

So I'm curious why the filter number seems so large in this band compared to what we would expect.

MR. WALKER: Okay. Yes. So there are two issues there. The width -- the side bands actually has to do with the width of the modulated carrier. So if I have a 10 MHz carrier, the side bands are going to be -- the first lobe is 10 MHz wide, right?

So lowering frequency doesn't make the side bands get narrower. It does make the filters better and that was a point I didn't get to is, yes, you can put dedicated filters for every one of these things and it might make it better.

You still have an issue that the filters drift and, Avago mentioned this, you have to put slop in the filters and that's part of the problem when you get up really, really close like right next door, you have to put in zero for the attenuation from your filter, because you've got to allow for the band tolerance. So it's a difficult problem.

MODERATOR HELZER: Okay. Thanks.

MR. WALKER: Yes.

MODERATOR PETERS: And let's hear from Tom Dombrowsky, CTIA.

MR. VERMA: I'm sorry, may I just step in to finish the --

MODERATOR PETERS: Oh, wait. I'm sorry, Tom.

MR. VERMA: I apologize. It will be quick. Yes, just on the filtering front. The question you had asked was if Band 25 can live with 15 MHz, why do we need 10, I believe? And that's essentially because it doesn't scale as linearly as you would hope, partly for the -- mostly for the reason Kent just said, which is that, you know, when you are looking at -- you know, these are mostly non-temperature compensated SAW technologies for low cost that is used.

And so you are talking about temperature drift and production variation that is factored in. And, you know, when William and his competitors give me a data sheet and I beg them for the best possible performance, you know, they require a certain amount of duplex gap before they can deliver it.

MODERATOR HELZER: Well, actually that -- I have to ask a follow-up for that, too. Maybe it's for William rather than for you.

MR. VERMA: Okay.

MODERATOR HELZER: But temperature variation, I have always heard quoted in parts per million per degree. So I would expect it to go down as well. Manufacturing variation, I don't understand, but I know the filters are larger, so I would assume at least on a percentage basis, the manufacturing variation will be smaller with this band.

So I don't -- I'm still not totally sure.

MR. MUELLER: Our experience is that you have three things that go into the space you want and the filter. One is roll-off, which is technology-based. We will put that one aside.

MODERATOR HELZER: Yes.

MR. MUELLER: The other two are temperature and manufacturing variation. And temperature is definitely proportional to frequency and percentage. And in our experience so is manufacturing variation. It is really part per million per, you know, frequency.

So what that says is the guard band in our experience does scale pretty well. The other side of the equation is what Sumit is pointing out, which is the differences in technology give you different capabilities and give you different cost points.

And classically, the lower frequencies have used lower cost point technologies that require a little more bandwidth. So that's the trade. It's back to the where do you want to, you know, spend the money in the design or how do you want to use the spectrum?

You can get guard bands down here as narrow as 5 MHz. It has been done. 5 MHz has been done at 700 MHz, so it can certainly be done at 6, but if you are looking for what is a cost-effective place, it's probably more like 8.

If you look at the SAWs that are being used right now, Band 20 has an 11 MHz gap at 800. You can scale it off of that and that's main scale, you know, SAW technology. So those are kind of where the industry is right now.

MODERATOR HELZER: And to be clear, I realize Band 25 is a challenged band. I'm not suggesting that we want to replicate that, but I just -- when you used the phrase as small as possible, I wanted to clarify it. So thanks. Thanks to both of you.

MR. MUELLER: Yes.

MODERATOR PETERS: Okay. All right. Let's finally go to Tom Dombrowsky, CTIA.

MR. DOMBROWSKY: Tom Dombrowsky. I'm here representing CTIA. And just a few quick comments. I think listening to the discussion here, I think my first take-away on this would be that a lot of this is a bit premature. CTIA is a wireless association. We are supporting both licensed and unlicensed services and are hopeful that both continue to prosper and do very well.

But until we get to the licensed paired spectrum frequency band sort of settled one way or another, it is going to be very difficult to sort of figure out what goes in the guard bands when you don't know what the size of the guard bands are and what the technical requirements for the guard bands are.

And I just want to echo what Ericsson and Christian said, which is we need to look at this very carefully once we have the band plan settled, then we can figure out what sort of unlicensed use might be possible in these guard bands.

MODERATOR PETERS: Yes. And I would just, on that point, point out that there is a whole group of stakeholders that aren't represented on this particular panel that may have conflicting views with many things.

So again, the reason that, you know,

this may be a subject of a future forum or workshop. Harold?

MR. FELD: And I actually want to state firm agreement with how CTIA just expressed this, which is, yes, obviously, you know, from a technical perspective and to agree with Avago, we are talking trade-offs.

The thing that I find rather startling about QUALCOMM's statement is the idea that no matter what the trade-offs, it would somehow never work out to allow unlicensed use in any of the guard bands, which strikes me as a rather profound feat of technical prognostication at this stage in the development.

I wish to caution against the sudden change in, you know, attitude that occurs when the subject of the unlicensed use of guard band is brought up when we suddenly go from well, there are trade-offs and maybe this size guard band, maybe this size guard band, this size guard band.

And then when we start talking about

other supplementary use, we've got no. If this is a technical question, I certainly agree that, you know, the trade-offs that drive this are driven by a multitude of factors.

But when looking at that, therefore, we ought to be conscious of all of the trade-offs that are taking place and keep an open mind, mindful that white spaces started a little more than 10 years ago today and was also considered to be impossible to accommodate, but we found ways to overcome the problems that were considered impossible then.

And I think that we should maximize the flexibility of use of the guard bands to the extent technically feasible and consistent with the primary licensed use, but mindful of the Commission's overall goals of promoting spectrum utility.

MODERATOR PETERS: Thank you. In the interest of getting a variety of speakers, Steve, you had your card up. Did you want to say something on this topic?

MR. WILKUS: It's been dealt with.

MODERATOR PETERS: It's been dealt with, okay. We will go to Sumit then. And we have got just a couple minutes left.

MR. VERMA: Sure. No, I'll make it quick. Regarding Band 25, Chris, I think your comment was fair in that the standard was then written to accommodate some roll-off in that 5 MHz beyond the PCS Band there. And essentially that is how a 20 MHz guard band became 15.

But yes, I mean, it is a challenge, but, yes, at the same time it is feasible. Band 12 -- I mean, William mentioned something interesting about 700 MHz. At least as far as I'm aware, most of the 700 MHz Band -- I think Band 12 is one of the most challenging and that is a 12 MHz duplex gap and it's not considered easy.

So, you know, I think that we just have -- we do have to be careful here. We took a pretty broad poll of a variety of vendors. You know, we didn't just take the word of one, so, you know, we really wanted to get to what was feasible here, because we have, I think, the same interests to try and optimize the spectrum as much as possible. Thank you.

MODERATOR PETERS: All right. I think that's going to conclude this portion of the workshop. We are going to take about a 15 minute break and meet back here at 3:30. Thank you all.

(Whereupon, at 3:14 p.m. a recess was taken until 3:34 p.m.)

MODERATOR PETERS: All right. Thank you very much. Welcome back to our final session of the band plan workshop. And in this session, we are going to focus on band plan trade-offs. And, as you know, we started off the day talking pretty extensively about the trade-offs between the various options.

And this is the part of the workshop where all the technical discussion that we have had up to this point comes together with a lot of the other aspects of incentive auctions, such as the auction design, the revenue that Harold was talking about.

And for this session, my co-Moderator is Evan Kwerel and I am going to pass the microphone to Evan to kick things off. Thank you.

MODERATOR KWEREL: Thank you. What I would like to do is to try to narrow the focus a little bit and do a, you know, comparison of two alternative band plans. The ones that are most similar and, you know, partly for simplicity and partly because there seems to be some consensus or more consensus on the down from 51 and the down from 51 hybrid.

But what I would like to be able to do is sort of do the -- compare them to some degree, apples-to-apples. One of the -- part of the -- my problem and the confusion is we often are talking about doing different band plans, but not holding constant anything.

And what I would like to hold constant is the amount of spectrum cleared. So what I would like to do is the thought exercise.

Suppose we clear more than 84 MHz of spectrum, you know, tell me about the pros and cons of these two band plans.

Suppose we clear exactly 84 MHz of spectrum, what are the pros and cons of these two band plans?

Suppose we clear less than 84, you know, how do these compare?

And I know this is sort of too many parts, but, you know, first the simplest case has to do with, you know, suppose we clear everything nationwide and we don't have any market-to-market variation and, you know, see if there is -- if one plan seems to dominate the other regardless of the amount of spectrum cleared.

And then the question is suppose that there is market-to-market variation, does that change the relative ranking of these plans?

So and then just the final kicker, just to -- so that Harold will be happy and because it's a good point, you know, sort of one way of summarizing this is when you are looking at for a fixed amount of spectrum cleared, you know, which one is going to raise more revenue?

Because, you know, we are now holding the amount of spectrum available, but then the amount of revenue, while not a complete measure of, you know, social value, does take into account both the costs in handsets, everything, because the more cost, the less people are willing to pay for it. And it also takes into account, you know, the benefits that carriers see, because, you know, they are willing to pay more if the customers are getting more value out of it.

So you know, having taken up all the time with my question, let me, you know, start at the beginning, which is -- so whoever wants to take this first in starting with -- suppose we get more than 84 MHz in addressing this has to say what the various others are for down from 51 hybrid.

Because if you look at the band --

down from 51, assumes everything is paired. You know, FDD paired. Down from 51 hybrid it's -- there is a fixed amount of paired spectrum, so there is certainty about that, but the rest of it is various. And the various, it says there, could be FDD, SDL or TDD.

So whoever answers it, pick the one that you think is the best alternative and then, you know, talk about it assuming we got more than 84 MHz.

Wow, people are just jumping. Christian is never shy.

MR. BERGLJUNG: Yes. I think that would be -- it should be the goal to go for more than 84 MHz, in the first place. And another goal should be, of course, the fungibility of the spectrum, so that we make at least the blocks as much as possible of equal value, so that that part of the auction can be carried out.

Also, comparing these two in our comments, we have advocated using down from 51 hybrid with the various part below Channel 37 as an uplink in an additional FDD Band. And we have also proposed a TDD Plan equally well according to the down from 51 TDD, also with two operating bands.

And we think that those solutions would address the intermodulation risks that we discussed earlier. And we have minimized the duplex gap to the feasible 10 MHz.

Now, for example, if we are looking at the 51 hybrid approach or any other approach for interoperability reasons, we think that all the UEs should be equipped ideally with the same amount of filters or operating bands, so that we have interoperability. And that should be according to a nationwide cleared plan for 120 MHz.

Now, if you do get less spectrum--

MODERATOR KWEREL: Well, before we go to less, let's -- suppose we have the more case. I just want to understand do you prefer the supplemental downlink or the TDD or how do we -- and what happens? Are -- the original paired

FDD, how much spectrum is in there? I mean, this thing is showing, you know, 25 up and 25 down. But what are you assuming about the additional paired?

MR. BERGLJUNG: Yes. Sorry for being unclear. In our proposal and what we are advocating for the band plan, for the full 120 MHz Band, we propose two down from 51 hybrid plan --

MODERATOR KWEREL: Right.

MR. BERGLJUNG: -- two FDD operating bands. And the upper band would be 2 x 25 MHz, I believe, 11 MHz of duplex gap. And the down -- and the second FDD Band would be 2 x 20 MHz Band, but it would also have a guard band to Channel 37 operations from below Channel 37 to protect the wireless medical services from uplink transmission, so -- if we allow the TX duplexers to roll-off and protect the wireless medical services.

And we would then also have a guard band depending on the adjacent TV transmitter for the 10 MHz guard band and below the uplink band below Channel 37. So it will be two FDD bands, 2 x 25.

MODERATOR KWEREL: I've got that. And if there is variability across markets, that would come out of that lower uplink?

MR. BERGLJUNG: Yes, it would. It would. So that would be where if only spectrum above 37 can be cleared in some market. That second operating band would then have to be, for example, combined with another band in those markets.

You can still use the downlink, but you would still use the downlink filter of that operating band.

MODERATOR KWEREL: Right.

MR. BERGLJUNG: And for our TDD proposal, likewise, we would have two operating bands, one above 37 and one below 37, also with a guard band to the wireless medical services. So we have supplied two alternative proposals should the Commission decide on FDD or TDD.

MODERATOR KWEREL: And if we were to -- so I think you have pretty much nailed this question. Now, do other people have different points of view on this one or are we all -- there is universal agreement here? Yes, Prakash?

MR. MOORUT: Yes. The only thing I would add with, you know, this proposal that Ericsson made is, you know, you are going to end up with two bands, solely for whatever reason. You know, the upper paired band becomes the preferred band by operators. I mean, you could end up with having, of course, a standard developing around one of the bands compared to the other one. And you can end up with a priority problem we had, for example, between Band 12 and Band 17.

So I guess my question is, you know, one way to get around that would be to have operators, you know, get blocks that is in the lower paired band and the upper paired band, so that then, you know, basically, you have to cover that the whole, you know, spectrum from the lower paired to the upper paired.

MODERATOR KWEREL: So you are saying that blocks would be bundled or something? I mean, or --

MR. BERGLJUNG: Randomly assigned.

MODERATOR KWEREL: Randomly assigned?

MR. MOORUT: Yes, randomly assigned. Exactly, Chris, yes. Because yes, if you -- it's two different bands, basically, so band -- you know, whoever gets the upper part versus the lower part will -- can be dictated how the system evolved.

MODERATOR KWEREL: Let me -- Christian wants to follow-up. Yes?

MR. BERGLJUNG: Yes, of course. There is a difference here in carrier frequency and I think that is regardless of the frequency arrangement that you would have. It may be preferential to get spectrum into various parts, but with the things that we are trying to avoid here is to, as much as possible, make these blocks of equal value, so that they meet the fungibility -- the idea of fungible spectrum in the auction.

And that is what we are trying to do in our two proposals.

MODERATOR HELZER: If I could just go back to Evan's original question, I think you were very clear. You know, he is basically comparing the blue and the purple and I think you are clear that you prefer, you know, a 25 + 25 up here and a 20 + 20 down here with 37 in the duplex gap.

But can you talk about why that is better than the blue where it would just be like 45 above and 45 below with 37 somewhere in the middle of the downlink?

MR. BERGLJUNG: Yes. We have also looked at the amount of spectrum uplink and downlink spectrum that you would get with these two proposals. And you would get then 2 x 20 and 2 x 25.

In the down from 51, that is

certainly one we considered in the process as well and that would then require a split duplexer arrangement in practice. So that would be two filters for the down and uplink and then you would have an additional operating band below Band 37 in that type of arrangement.

So that would increase the count of components and bands in your part. So hence, that's why we proposed the down from 51 hybrid and the TDD approach.

MODERATOR KWEREL: Let me just put out something that we have talked about which doesn't really, you know, address the -- whatever -- the split band. But you know, the down from 51 to deal with variability and how much we clear in different markets, you know, one proposal or suggestion was that we would flip the uplink and downlink similar to what, you know, you have proposed in the lower band, so that if there is cross-market variability, it would come out of the uplink.

Does that at least -- I'm not saying

that it makes down from 51 preferable, but at least make -- improve down from 51 as proposed.

MR. BERGLJUNG: Yes. It would also depend on the, obviously, downlink, the pass band of that aggregate band that would then stretch, but potentially be below Channel 37, if I understand your proposal correctly.

MODERATOR HELZER: Well, just since you said if you understand correctly. Yes, I think what Evan is saying is one of the trade-offs we want to talk about is this least common denominator problem and this need to support constrained markets and that in some of the plans, there is a lot of tension against the idea of TV in the duplex gap, you know.

It is much easier to support the constrained markets by reducing the uplink and putting TV in the duplex gap. We have heard a lot here about how that is difficult. But if they were reversed like the lower band in your plan, then you can vary the uplink without putting TV in the duplex gap.

So the question is does that maybe then allow you to get -- instead of having to choose between market variation and down from 51, does that allow you to get both or more -- or get them both more easily? Because the -- everybody has some form of market variation with their proposal. I think that is -- I also see a ton of cards over there. I don't know.

MODERATOR KWEREL: I just want to reply to that.

MODERATOR HELZER: Oh.

MODERATOR KWEREL: We do have a whole bunch of -- did anybody pay attention to who put their cards up first?

MODERATOR HELZER: Darryl was pretty early, so was Rick. I'm not sure. They were while you were still talking, Evan.

MODERATOR KWEREL: All right. Darryl?

MR. DeGRUY: Hello. This is Darryl DeGruy. I want to address one point. You talked about flipping uplink and downlink, that would create an uplink/downlink transition with the lower 700 MHz Band adjacent to A, which would, you know, potentially cause some concern and possibly lead to a guard band, the necessity of a guard band at that point.

So I just wanted to point that out. And then I want to make sure in the down from 51, are each of those blocks in uplink and downlink 45 MHz or is it --

MODERATOR KWEREL: So you want to address that?

MODERATOR HELZER: Well, I think since Evan just sent it back over to me, in the down -- I mean, the 45 + 45 I just mentioned because Evan and Christian were talking about the case of you clear 120.

I think the only distinction between Christian's version or Ericsson's version of the purple and the blue, in that case, is whether it is 25 + 25 up here and 20 + 20 down here or 45 up here and 45 down here.

Now, in some of the other proposals

from some of the other companies, there is more difference between those plans, because Ericsson is one of the few who recommends that the second band be paired.

But the 45 was just for that example. There is -- the idea in the blue is that if you get 50 + 50, then it is 50 duplex gap 50, etcetera.

But also to your comment about the guard band, I just want to mention very briefly that I think you probably would need a guard band, right, between -- if you put the uplink there and the downlink there, you would need a guard band.

But on the other hand, you are -- then the other guard band between wireless and TV is an uplink to TV guard band and most of the commenters seem to think that is a lot smaller. So it's not necessarily a huge difference in the total amount of guard band that you might have.

MR. DeGRUY: Okay. So in that case, the uplink would be immediately adjacent to TV and the base station receiver would be direct line-of- sight to potentially TV broadcasters because antennas on base stations are typically high in the air and so that receiver doesn't have the benefit of clutter being lower on the ground, buildings, trees to block the signal, etcetera. So that is another concern with flipping those.

Again, US Cellular would like to see as much spectrum offered as possible and I appreciate the debate here over whether we go down from 51 or the hybrid plan that benefits those two. I think that it comes down to the cases of where we have less than 84 that potentially might lead us to more discussion about how do we take care of areas where there may still be TV stations inside either one of those bands.

And Christian was saying that, you know, in the Ericsson proposal you would be able to concentrate that on one side of that one uplink/downlink pairing at the higher side. And I agree that other comments that were made, interoperability needs to be definitely put in place, so that carriers are -- devices support both sides, the uplink/ downlink one, uplink/downlink two per their proposal, so that devices can tune, devices and networks that are in those areas, the mobiles that are supported on both.

MODERATOR PETERS: Just on that point regarding the co-channel assignments of DTV and mobile broadband uplink frequencies, part of our thinking and, unfortunately, this didn't come up this morning, but one of the things that helps make it that is that, you know, base stations aren't as sensitive to economies of scale as devices.

And so individual base stations in a market that are only using a portion of the uplink spectrum can be filtered to see only that part and thus filter out the adjacent TV stations that might be in-band to, you know, the rest of the band.

So, you know, we kind of see that as a potential way to mitigate that interference.

MR. DeGRUY: Understood. Thank

you.

MODERATOR KWEREL: Thank you. I am just going around. I don't remember who -- I didn't even see, so, Karri?

MR. KUOPPAMAKI: Thank you. Yes, so a very quick comment. I think the -- if 120 MHz is cleared nationwide, then at least on the surface this two pairs makes sense. But then at the same time, if there is market variability and you start eating into your uplink, the other pair breaks down relatively quickly, which would mean that the 20 MHz that is reserved for downlink, you know, what do you use it for?

And hence that's something to keep in mind that I think it's more likely that there will be market variability than not, in which case maybe this down 51 plan is something that will make it easier to maximize the amount of spectrum rather than the hybrid trying to maximize it through having two pairs.

And, yes, there are benefits in terms of filter implementation and all that stuff, but at the same time, we talked about that maybe not being the biggest issue under the sun. And maybe the future developments will help alleviate that even further. And, you know, it's just one thing to keep in mind that these things break down, too.

MODERATOR KWEREL: Chris, I mean, if we have market variability, don't we have the same issue in the down from 51?

MODERATOR HELZER: Well, I --

MODERATOR KWEREL: You know, in our thought -- at least with our original down from 51 and 36. We were talking about supplemental downlink in those places, you know, where you don't -- you know, you had to match.

MODERATOR HELZER: Sure, sure. I mean, one of the ideas in the NPRM that was generally well-received by commenters was if you want to try to support market variation, it is more important to hold the downlink uniform than the uplink uniform for the reason Tom was just talking about.

That being said, the NPRM originally

also mentioned the 4 percent issue, but was very focused on a single band. And to the extent that you are doing multiple bands anyway, that's another way to attempt to support market variation, but it's probably not nearly as granular, because if each band is 20 MHz supplemental downlink or 25 + 25, you have much less granularity that way.

But any amount of market variation you support a proposal where some people said oh, well, you should clear this much and then if in more markets you get more spectrum repurposed, make it supplemental downlink and that, of course, creates co-channel assignments because your supplemental downlink is in some and not others.

In the proposals where you vary the uplink, you again get co-channel assignments. Any market variation by definition has co-channel. You have some markets where it is TV and some where it is not. There is a lot of variation in the different plans on exactly how it works out.

Hopefully that answers -- it was Evan's question. I was answering Evan's question.

MODERATOR KWEREL: QUALCOMM?

MR. WALKER: Yes. Certain aspects of Ericsson's approach are appealing, at least as I listened to it. It was modular at 20 or 25 MHz, which is a good thing from the point-of-view of the filters.

The top 25 MHz through all of our analysis is held up as being far and away the best spectrum for uplink, so we would recommend whatever you do, make this uplink.

Beyond that, we see SDL below that pair as the best choice in terms of not causing additional guard bands and giving the operators an opportunity to get more downlink bandwidth, which is -- we thought of that a few times already. So I'll pass from there.

MODERATOR KWEREL: So, Harold, and then I hope you are going to respond to that. Oh, I forgot, let me get Harold and then I'll get you and then you. Okay.

MR. FELD: A couple of things. First, lest we run out of time, I do think it is important to point out that among various trade-offs that need to be considered are everything else that the Communications Act explicitly says, including competition.

MODERATOR KWEREL: Right.

MR. FELD: Blah, blah, blah. So hopefully we will get back to those. But with regard to this and particularly with the spectrum reclamation for repurposing, based on the technical considerations that we have been talking about here, first of all, it is not at all clear that going beyond 84 MHz recovered maximizes revenue, unless you are reaching some larger break even point like 120.

But the reason for that has to do with the fact that the revenue is determined, in no small part, by the cost to the -- the revenue to the US Treasury has to factor in the cost of the relocation cost of broadcasters and what it takes to drive the broadcasters off of the spectrum.

One of the biggest problems with this that the Congressional Budget Office identified is that, to use their terminology, "Broadcasters must be induced to release their spectrum rights at a cost below fair-market value," which is problematic because if it were just a straight up fair-market value trade between the wireless companies and the broadcasters, there would be nothing left in between, which is where the Government makes its nut.

So the problem you have here, as we have been hearing, is that when you start to get into supplemental downlink, because we have added some additional spectrum past Channel 37, that may be enough to drive broadcasters to demand higher prices to clear, because the Government has advertised it will take all of its -- all the spectrum it can get and, therefore, they have no reason to abate their bidding.

MODERATOR KWEREL: Chris?

MR. FELD: Okay. I'm sorry. Am I getting too --

MODERATOR KWEREL: But some of this can be determined in auction.

MR. FELD: Yes.

MODERATOR KWEREL: We just need to start with a band plan based on sort of the maximum amount we can clear and then find out how much.

MR. FELD: Right. And I recognize that is where this gets all complex. But one of the advantages you have of the channel -- of the 51 and 36, which was the original --

MODERATOR KWEREL: Right.

MR. FELD: -- band plan, is that it does tend to work against the concern of this two-tiered auction problem. And I think that that really needs to be taken very seriously, especially given that we have a much smaller potential bidder pool. We have a more cautious potential bidder pool. The question of whether if Verizon, AT&T are not in any way constricted in the auction, whether other bidders bother to show up at all.

And particularly if there is a two-tiered auction, the experience from previous auctions shows that everybody else gets driven down to the lower tier and it just overall reduces the return.

MODERATOR KWEREL: Okay. So let me call on Sanyogita.

MS. SHAMSUNDER: So I think we are still talking about 120 MHz cleared minimum? Okay. That's the starting point. I just wanted to --

MODERATOR KWEREL: No, I'm interested in --

MS. SHAMSUNDER: -- clarify because we were --

MODERATOR KWEREL: I'm interested in knowing at all different levels. I mean, but I think that, you know, Christian did address, you know, how he would scale back.

MS. SHAMSUNDER: Okay. Well, let me start from 120 MHz period. I think if there is an option to split the uplink/ downlink pairs into above 37 versus below 37, we would like to keep everything above 37. So that means going as much as 35 by 35, although the 25 by 25 is the neatest, we may have to compromise there and additional spectrum would be supplemental downlink.

I mean, I hear Christian's point in terms of adding another uplink to the left, but that really means that impacts the antenna design. Furthermore, you are further shifting the, you know, bandwidth of the antenna down and then that's the uplink which would, you know, necessitate a better response at the uplink.

So I think that's challenging. So I would rather advocate doing the 35 by 35, keeping to the right of 37 and doing additional supplemental downlink from that point onwards then.

MODERATOR KWEREL: Okay. So that's when we get, you know, less than 84. Just 84 exactly.

MS. SHAMSUNDER: Yes.

MODERATOR KWEREL: Yes, that's the case of 84 exactly.

MS. SHAMSUNDER: That is 84.

MODERATOR HELZER: She said if we do more than 84, she does not think any more pairs should be created.

MODERATOR KWEREL: Right. But if --

MS. SHAMSUNDER: Right. Yes, correct.

MODERATOR KWEREL: Okay. Christian?

MR. BERGLJUNG: Our viewpoint is that we should -- and I think most of us agree, we should try to maximize this to 120 MHz of spectrum. That should be our primary goal and recognize that in some markets we may not be able to reach that goal, but that should be the goal. And preferably, also, be a nationwide spectrum plan.

From the Ericsson side, we have

already -- we have always had the fungibility of spectrum in mind when devising our two proposals for the FDD and the TDD Plan. And that also means that those parts of spectrum should have about the same value which would also be important in an auction process.

And if we specify some part of the band or a considerable part of this band as a supplementary downlink band, it may be difficult to say that this is actually fungible spectrum, because there will be a difference, clear difference in spectrum value.

And as regards to technical feasibility, as we have discussed earlier, yes, of course, it is a challenge for the antenna, for example, to go down below 37, but we would also say that that applies both for the transmitter and the receive side.

So with fungibility in mind, we think our preference has been to allocate the spectrum as either two FDD Bands or two TDD Bands.

MODERATOR KWEREL: Okay. William?

MR. MUELLER: I just want to point out that in 51, if you clear more than 84, because 37 now becomes inside of your receive band, you have a variable duplex gap and that can complicate the radio a lot. So that's --

MODERATOR HELZER: I think you have variable duplex spacing, but not a variable duplex gap.

MR. MUELLER: I'm sorry. Spacing, correct.

MODERATOR HELZER: Yes.

MR. MUELLER: But that's my simple point that if you extend below it with the receive band, then your radio is quite different.

MODERATOR KWEREL: Okay. Steve?

MR. WILKUS: Yes, thank you. You had asked earlier if we were in general agreement and I'll just say that Alcatel-Lucent's proposed band plan that we spent some time discussing in the January comments were very much, I think along the lines that Christian had talked about.

It is basically the hybrid down from

51. What we had -- we had tried to suggest was that the uplink at the top end of the band should not exceed 30 MHz of bandwidth. Maybe not 20 -- maybe even just 25 MHz based on the filter judgments of the filter bandwidth capability, but not more than 30 because then that starts to get into the third harmonic problem with the PCS and the spectrum ceases to be interchangeable.

But it's also true that the principle is violated when we go to the low -- the downlink section of the band below a 10 or 12 MHz duplex gap, because it is -- you know, there are some paired channels there and then some supplemental part of the spectrum that may have different value and ceases to be strictly fungibly interchangeable.

We had also pointed out in our comments that the below 37 could be -- if it was all TDD, it would also work, but you can't intermix the TDD and the FDD without a 10 MHz guard band of the sort that Channel 37 helps provide.

But because of the interference with

the medical telemetry, we had proposed a guard band just below Channel 37 if TDD were to be used. So I think I'm reiterating support, but with -- perhaps said a little differently and with a few other points here on say the role of TDD or the -- and some of the fungibility questions that do arise and the interchangeability.

MODERATOR KWEREL: Good. Harold?

MR. FELD: The problem of market variability, I would suggest that particularly when you start to get extreme variability, you will start to run into problems. For – one, of the commonality of handset design as was mentioned before, but there also becomes a question of a real -- you know, the value of the return.

We can all agree that there are a lot of rural markets where you could get 120 MHz right now without needing to clear out any television stations, because, you know, they have got four stations. But you are not going to get a significant return in those markets for anything that is auctioned.

If you are going to go with market variability, you probably want to think about how to limit the quality of the return in order to adjust for these considerations.

MODERATOR KWEREL: Good. QUALCOMM substitute, technical expert? Kent?

MR. WALKER: And I'm actually speaking in Sumit's behalf.

MODERATOR PETERS: Could you speak into the mic?

MR. WALKER: Sorry. I'm speaking in Sumit's behalf. One of the things that QUALCOMM is continuously approached on from OEMs and operators is support for carrier aggregation. And SDL is a very valuable resource to operators. So I don't think it should be considered as disadvantaged spectrum in any means whatsoever.

MODERATOR KWEREL: Okay. After -- thank you. After Rick's question, then we are going to have a chance for other people to just sort of have a wrap-up. And Tom will explain that. Rick?

MR. ENGELMAN: Thank you. Well, I wanted to go back to that. I mean, I think part of the concerns that we have expressed and continue to share is supplemental downlink is anti-competitive, unless you have enough opportunity for competitors to be in the band. It just helps no one. It really is going to be valueless spectrum except for those few who get access to the limited spectrum there.

So I think that is our concern and continues to be our concern with SDL. And it is why -- although it is not one of the two you asked us about. I will comment on once again that the fourth one on the band deals with a lot of problems that people just expressed about these two plans.

It doesn't force you to make those same kinds of choices in the same way. And it does, we think, merit consideration still. Thank you.

MODERATOR PETERS: Okay. Thank you. So we have assembled a very distinguished and large panel of experts and we have heard a lot of discussion today about the technical challenges and trade-offs and it's often a very interesting discussion.

But what I'm interested in closing the day with is getting final thoughts from those panelists that would like to provide them. But also I want to make sure we hear from some of the people who haven't participated as much during the day.

So maybe, Dale, would you like to give us some thoughts? Thank you.

MR. HATFIELD: Thank you. I have not said much and it is in part usually I'm working a layer higher in the protocol stack and I have learned an awful lot and so, therefore, I really -- and my students will benefit, so I really appreciate being invited to hear, be able to listen in person.

I don't think I have anything particularly profound at all listening in. There is one point I would like to make and that is regarding one of my current hot topics, in my own mind, is enforcement issues.

And what we are hearing about here is jamming more people into the spectrum that we have in some really complex systems to be able to try to sort it out. And I think there is a chance that we may make mistakes that we may get things wrong. And what that leads me to is back to the enforcement idea that maybe now we truly now begin to think of enforcement, because in some of the cases here we are talking about with the hospitals, for example, is very critical.

Other things are very subtle. Harmonics and things like that may be subtle interference to TV and so forth. Those are all things that we may have to deal with.

And so I guess if I was -- since I'm housed in the law school now which is -- so I'll use the Latin. You know, what we focused on here is an awful lot on the ex-ante situation, but we are going to have to make some adjustments later on and enforce the rules that we develop and so forth.

So I think it's probably not too early to begin thinking a little bit about what happens after we have actually gotten through the auction and so forth on the enforcement side.

And with that, the other thing is I think we probably won't get it quite right economically either and I'm looking at Evan when I say this. Can we do things that will allow marketplace adjustments after we do this, because one of the things that really impressed me is to say filters are changing, the duplexer things, everything is changing.

And so anything that we write into concrete now is probably going to be wrong a couple years later. And so how -- what could we do now that may be able to facilitate voluntary negotiations among parties of these adjacent bands later on?

But what I've just said shares the -- a common thing here is the ex-ante thing. What we are dealing with now, we shouldn't forget the ex-post of what will happen after we actually go ahead and make the decisions.

So thank you very much for the opportunity of adding a little bit here at the end.

MODERATOR PETERS: Yes, thank you very much. Delroy, do you have some closing thoughts?

MR. SMITH: Yes, I just want to thank the Commission for its creativity in putting together these various plans. I personally like down from 51. I don't believe that we would need a guard band for Channel 37.

In looking at the hybrid plans, I think I like the idea of having a guard band around Channel 37 and you can put some white space next door. I think that would work fine. And likewise, in the 51 TDD, some guard band around 37 with white space adjacent to it, I think, would probably be okay.

So I think, you know, although 37 is a little rigid, but I think I was really pleased to see some of the members here really trying to work towards coexisting with that.

MODERATOR PETERS: Okay. Thank you. Rick? Anybody else? Victor? Jay? Any closing thoughts on the day?

MR. TAWIL: Just a comment maybe not a thought. But I do think that a lot of people are looking in terms of getting 84 MHz of band out. And we have to refocus a little bit and maybe Evan talked about it.

In the event you get less than 84, what is the most appropriate plan? I think that's important. You might be starting from a high standard. Start thinking about what would be a viable plan between the two services, if you get less than that, and develop your band to that consideration.

The other one is actually I wish things were a little bit different. It's a lot easier to know how much spectrum you have vacated, I mean, under reverse auction. Then you develop a plan. Well, maybe we're doing it a little bit backward here, but it would be nice to know, you know, what is available, then develop optimum plan that is viable for both industry.

Develop and establishing the downlink size at that stage is probably premature, but we have to do it. That's my two points.

MODERATOR PETERS: Okay. Thank you very much. Brian?

MR. MARKWALTER: Thank you. And so the only thing I was going to add is that when CEA talked to our members, I think it is just about every kind of party represented here plus others that you may have on some future discussion related to unlicensed, but the one thing that was in common was that the down from 51 and down from 37 plan was unappealing.

I don't think any of our members were in favor of it, that includes TV manufacturers and on the wireless mobile side. I think the other thing to remember though is a lot of this discussion has been forward looking about complexity of our mobile broadband systems, but we still have, you know, 300 or so million TVs out there that have been designed around ATSC and, in particular, A74 kind of reception expectations.

Those still need to work when we are done. And we can argue about what percentage use them, but, you know, you can assume that in any big DMA, there is going to be some percentage using them and they are going to be scattered around.

Well, we don't have great data on it. I think the last point is, you know, we don't -- nobody controls what antenna they hook -- consumers hook up. They are not sold together, unlike handsets, you know, where you get that sort of design the whole system so to speak.

You don't know what antenna is going to be connected. In fact, it has been hard for us to figure that out. And even though, you know, I agree with Victor that the fringe is, obviously, a difficult situation because the field strength is just limited there, my assumption is that as you get closer in, the consumers are -- you know, they are-- in fact, there is like antenna web. You get recommended a smaller and smaller antenna or omnidirectional or whatever.

And so the actual input to the tuner, I mean, you may have a better situation, but you shouldn't assume that, you know, once you get inside a certain range, it all, you know, becomes okay.

MODERATOR PETERS: Yes. Okay. Thank you. Harold?

MR. FELD: Yes, just -- while I passed over it briefly before, I do just want to add and stress that, yes, there are a lot of other factors. We have talked about the technical factors here in the band plan trade-offs and we have talked a little bit about the revenue issues.

But there are clearly a large number

of other concerns, the competition concerns loom very large. The fact that I think that the pro-competitive policies are also probably the revenue maximization policies, but even if I'm wrong on that, these are obviously things that need to be considered, as well as maximum utility out of the spectrum, which again I'm glad that there will be an opportunity to have some discussion about guard band unlicensed services in this regard, because these are important factors, recognizing we can't squeeze all of those in here today.

MODERATOR PETERS: Yes, yes. Thank you. Good point. David?

MR. STEER: So I'm not quite sure what I'm actually going to say here, but the-- so in looking through the reply comments and the -- what essentially are the, in summary here, blue and the purple ones, those were the proposals which when I saw them, I thought yeah, those are moving in the right direction.

And so perhaps to add to the

discussion that has just occurred, those -- some arrangements along those lines seem like a good way to go.

And I guess the sort of closing comment that is really important to us is that don't have too many variations in it. And so when you do get to the case where it is less spectrum that's available, hopefully that fits in, so that we can build one device that does the whole thing, because we don't want to be getting into the mold where we are in at least one of the other bands or we have to build three or four different devices for the different suppliers.

And so we really are hoping that whatever the arrangement is we only have to build one of them. Thank you.

MODERATOR PETERS: Thank you. That is a good trend towards minimizing the number of SKUs, I think. That's a good point. Prakash?

MR. MOORUT: Yes. It is supposed to be a technical workshop today. So, you know, I haven't heard really any major technical constraints other than having TV in the duplex gap.

You know, the other issues mentioned, you know, intermodulation, interference with TV, and even the FDD/TDD coexistence seem manageable with various mechanisms and, you know, coordination, filters, guard bands, etcetera.

So I think, you know, for blue or purple and even the orange, I know it's not helping you, but all these band plans, you know, look reasonable. You know, I don't think the FCC was expecting to hear something different from, basically, you know, what I'm saying.

I don't think we have reached any consensus today. And I'm not sure if that was a goal either. But I think all three band plans, you know, are reasonable, including one we don't have here. It could be -- and I have heard some, you know, people say about, you know, we don't want to mix FDD and TDD, but, you know, if you do things properly and you segregate the TDD in one part of the spectrum and the FDD in the other part, yes, you need a guard band. You need filters.

But you need filters with TV and other systems any way. There might be ways of maybe, you know, communicating, you know, with the TDD and FDD and maybe, you know, one TDD operator and then several FDD operators in that band.

So I guess, you know, we just need to be open minded and also make sure that we come up with a band plan that allows, you know, interoperability also. So thanks.

MODERATOR PETERS: Excellent. Thank you very much. Last call for final comments. Anybody? No?

All right. Well, I want to once again thank you all for coming here. I think it has been a very useful and fruitful day.

One side note, we didn't tell you beforehand, but we have been keeping track of how many times you mentioned the word fungibility and, Christian, you won that prize by a long shot.

(Applause.)

MODERATOR PETERS: But no, thank you again very much for coming. A round of applause for our participants. Thank you.

(Applause.)

(Whereupon, the meeting in the above-entitled matter was concluded at 4:22 p.m.)

C E R T I F I C A T E

This is to certify that the foregoing transcript

In the matter of: Learn Workshop - 600 MHz Band Plan

Before: FCC

Date: 05-03-13

Place: Washington, DC

was duly recorded and accurately transcribed under my direction; further, that said transcript is a true and accurate record of the proceedings.

Neal R Gross

Court Reporter